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THE ARCTIC INSTITUTE OF NORTH AMERICA

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Photo: J. J. Languepin

The ablation zone of the Ice Cap in August 1948: some five miles inland (altitude 2500 ft.)

THE FRENCH EXPEDITION TO GREENLAND, 1948

***By* Paul E. Victor**

OUR idea of an expedition to the Greenland Ice Cap, for the purpose of studying its characteristics and its influence on the atmospheric circulation of the northern hemisphere, dates from the years before the Second World War.

Leaving France in July 1934, I had spent one year at Angmagssalik on the East Coast of Greenland, in company with Robert Gessain, Michel Perez and Fred Matter. Gessain, Perez and I then returned to Greenland in April 1936, and made a dog sled journey over the Ice Cap from near Christianshaab to Angmagssalik. On this journey we were accompanied by Count Eigil Knuth of Denmark, who is at present the leader of the Danish expedition to Peary Land. During this west-east crossing we were constantly confronted by the challenging problems of the Ice Cap, which the Wegener Expedition of 1931 had shown to be in places between one and two miles in thickness. In particular, our glaciologist, Perez, became eager to make a traverse of the Ice Cap on which it would be possible to take sufficient equipment to obtain the necessary data for drawing profiles of the substratum.

During the war, I was an officer in the U.S. Air Force, and was stationed with the Search and Rescue Squadron in Alaska. Here I became familiar with parachuting techniques and the performance of aircraft and weasels under northern conditions. I soon realized that by the use of an aircraft and mechanized vehicles it would now be possible to transport the heavy equipment necessary for the work we had contemplated in Greenland.

At the end of the war I put my name down for some surplus weasels, and immediately after my return to civilian life, with four others I began to make plans for an expedition to study the Greenland Ice Cap. In addition to Gessain and Perez, the group included Raymond Latarjet and André F. Liotard. The idea was widened and to make our ice study more complete we planned that an Antarctic Expedition with Liotard as leader should be made simultaneously with the Greenland project.

All the necessary authorizations for the expedition were generously granted by the Grønlands Styrelse, in May 1947. The expedition was to be a private one but we received official financial aid from the French Ministry of Education, Department of Scientific Research, and assistance from other interested persons.

The research program was discussed and adopted by a scientific commission presided over by M. Charles Maurain and R. P. Pierre Lejay, both of l'Institut de France. The research program, which was approved

by l'Académie des Sciences, was as follows:

To obtain profiles of the surface of the Ice Cap by precise methods.

To obtain profiles of the substratum by seismic soundings.

To study problems of glaciology particularly:

accumulation and ablation of the névé;

the temperature, density and stratigraphy of the surface and deeper layers of the ice.

To make gravity measurements and obtain gravimetric profiles.

To make meteorological and climatological observations.

To study atmospheric optics.

It was also hoped that research would be possible on a number of biological problems.

The detailed organization of the expedition was begun on 1 October 1947. It was planned to divide the operation into two successive stages: a preliminary expedition in the summer of 1948 and the main expedition which would take place during 1949, 1950 and possibly 1951.

The members of the expedition were to be divided into two main groups:

A Summer Group working inland during the summer season occupied with geodetic surveys, seismic soundings, gravimetric measurements, and certain problems of glaciology. A small party would carry out coastal researches for the expedition. The Summer Group would consist of twenty to thirty scientists and technicians. The technicians were to be responsible for radio, machines of all kinds, vehicles, and photography. The Summer Group would spend the summers of 1948, 1949, 1950 and, if possible, 1951 in Greenland.

A Winter Group of from 6 to 10 men who would make year-round observations at the Central Ice Cap Station. This station would be erected as close as possible to Wegener's 1931 *Eismitte* station (approximately 71°N., 41°W.), in order to benefit from the records obtained by Georgi, Loewe and Sorge during their almost complete year of observations there in 1930-31. The researches of the Winter Group would mainly relate to climatology and meteorology and to certain glaciological and geophysical problems. It would spend the year 1949-50 at the Central Ice Cap Station, and, if possible, would be succeeded by another group for the year 1950-51.

This paper will deal mainly with the work of the 1948 preliminary expedition. The objectives of this expedition were to bring up to the Ice Cap the heavy equipment necessary for the main expedition in order that work might start as early as possible in 1949, and at the same time to familiarize the members of the main expedition with the region. This would enable them in some cases to initiate their research programs and also to improve their instruments and technical methods during the

following winter in France. The purpose of this preliminary expedition, it should be stressed, was to ensure that everything and everybody would be thoroughly prepared for the main undertaking during 1949-50.

THE PRELIMINARY 1948 EXPEDITION

On 14 May 1948, some six months after preparations were begun, the 25 members of the expedition, with their 90 tons of equipment, sailed from Rouen aboard the Norwegian freighter *Force*, which had been chartered for the purpose. To permit our gravity expert, Jean Martin, to make comparison of the relative values of gravity between Europe and Greenland, the *Force* put in at Edinburgh, Godthaab, Godhavn and Jakobshavn. Some scientific observations were made on board ship, particularly by Philippe Pluvinage our geophysicist and Michel Bouché our meteorologist.

We had the choice of four main landing places on the West Coast of Greenland:

J. P. Kochs Land, (72°30N., 54°W.), where Koch and Wegener came down from the Ice Cap after their crossing in 1913.

Kamarujuk Glacier (71°N., 51°W.) which had been Wegener's starting point on to the Ice Cap in 1931, and Arne Hoygaard's starting point for his crossing in the same year.

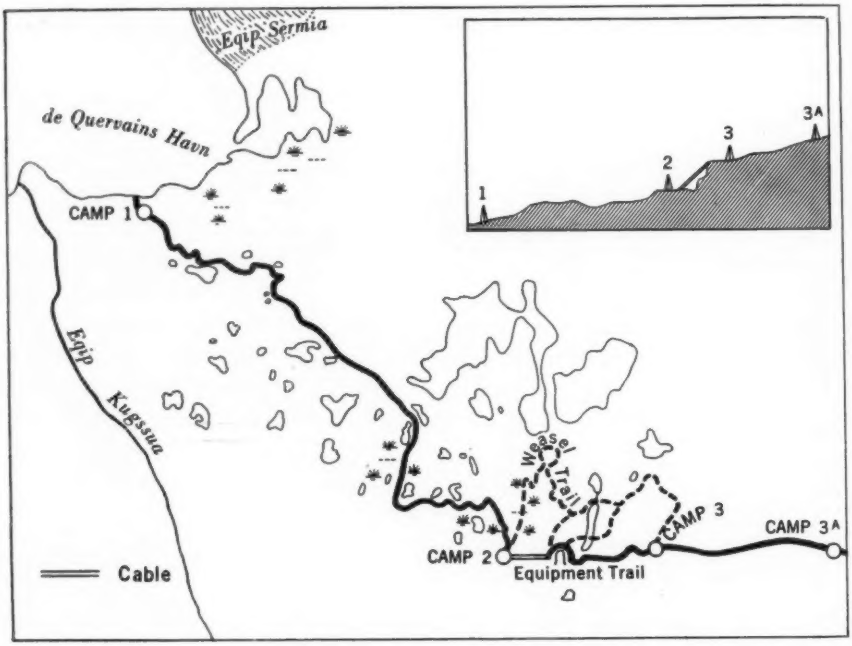
De Quervains Havn (69°48 N., 50°15 W.) from which de Quervain in 1912 and Lindsay in 1934 had started for their crossings of the Ice Cap.

Akugdlit (68°40N., 57°W.) where my companions and I had begun our crossing in 1936.

At our request, several Eskimo parties had made numerous reconnaissance trips by dog-sled to these different points during the winter of 1947-48. Their findings had been reported to the local Danish authorities, then radioed to the Greenland government in Copenhagen, who in turn had passed on the information to us. These reports and the infor-

mation collected locally as we sailed north decided us to visit first the point where de Quervain had landed in 1912. There we hoped to find good anchorage and fairly good landing possibilities. This point moreover is only six miles as the crow flies from the Ice Cap.

On June 1 the *Force* dropped anchor in front of the Eqip Sermia Glacier (69°46 N., 50°15 W.) in a fjord almost free of ice. Although 600 miles farther south the land was still covered by snow, here it was remarkably bare.



The route from Camp I to Camp IIIa.

Reconnaissance parties set out immediately to examine possible routes to the Ice Cap. These proved to be very difficult because of the abnormal absence of snow and it was soon evident that the route followed by de Quervain in 1912 would not be possible for weasels. After forty hours of continuous reconnaissance we discovered a new route which would, with some improvements, be practicable for our ascent. The most difficult obstacle was a 500-foot cliff, but we had foreseen this and had brought with us a specially constructed cable-way for lifting supplies.

Landing Operations

We began unloading our equipment on June 3. The rocky coast and the great waves caused by the blocks of ice which calved from the glacier

made our task difficult. But with the exception of one of our landing boats, which capsized when struck by a wave, and a weasel, which was lost when its raft hit a submerged rock, the 90 tons of equipment were all unloaded safely. The twenty-five members of the expedition, with the assistance of fifteen Eskimo, built two landing piers and completed all unloading in six days. On June 8 the *Force* was able to leave for the summer cod-fishing off Iceland.

The expedition was to be entirely mechanized, and in addition to

Photo: J. J. Languepin

Weasel on the Ice Cap: heavy going in the ablation zone, July 1948.

scientific instruments and camping material our equipment included:

7 weasels (M 29C): one lost in unloading

14 duraluminum sledges, approximately 13 x 6½ ft., to be towed by the weasels

3 trailers on sleds, approximately 13 x 6½ x 5½ ft., for use as laboratories

3 winches

12,000 ft. of various metal cables for the cable-way

5,000 gals. gasoline

radio sets

food for 25 men for six months on a scale of 5,000 cals. per man per day.

Photo: J. J. Languepin

Surveyors at work near the coast. In foreground snout of the Eqip Sermia, June 1948.

Photo: J. J. Languepin

Laboratory trailer being towed up to Camp II, some two miles distant, July 1948.

Photo: J. J. Languepin

A load being hoisted up on the cable-way, 13 July 1948.

Camp I

The site selected for Camp I was on a platform some 150 feet above sea level. This was to be the permanent camp of the 1948 and 1949 Summer Coast Parties. We planned to sort out equipment intended for the Ice Cap at Camp I and to use it as a depot for reserve stores for the 1949 expedition.

All our equipment was carried up to Camp I with the aid of a winch, which could take one ton at a time. On June 9, while this work was in progress, two members of the expedition and five Eskimo set out in a weasel to survey the proposed route to the Ice Cap. We had decided that some 43 tons of supplies would have to be carried up from Camp I to the Ice Cap. This great weight of supplies combined with the necessity of keeping the weasels in good condition for 1949 required our building a reasonably good trail.

Our method was for a few men on foot to stake out the most suitable route. Another group travelling by weasel then marked the trail with cairns, approximately 16 feet apart, on the driver's side going inland, to enable travel in fog, and also removed the largest rocks and stones. Finally several teams improved the surface of the trail, blowing up rocks and building necessary bridges and piers.

The five miles of trail from Camp I to the site for Camp II were completed by June 19. The route traversed many different types of terrain, and many natural obstacles such as rock-bars, small lakes and swamps were safely negotiated.

Camp II

On June 20, the first convoy, consisting of four weasels with two tons of supplies, left for Camp II. Camp II was planned as an intermediary camp and was set up at the foot of the 500-foot cliff mentioned earlier. The weather, which had been very good, deteriorated at this point, and we were further hindered by the appearance of innumerable mosquitoes. In spite of this the remainder of the supplies was brought up in fifteen convoys of six vehicles each, working on a schedule of 6 hours driving and 8 hours rest, the latter including loading and maintenance. It took as much as 40 consecutive hours of work to transport the three trailers to Camp II.

Work was started on the route from Camp II to the site selected for Camp III, on the Ice Cap, as soon as the earlier stretch had been completed. This part of the route necessitated the construction of two separate trails: the first, for the transport of equipment, by cable-way to the top of the cliff, and then across one mile of trail to Camp III; the second, for the weasels, which had to find a way round the cliff, by some 2½ miles of trail from Camp II to Camp III.

The cable-way had been specially built for us in France by the Compagnie française des Funiculaires de montagne, at Chamonix. As its installation involved calculations which could be made only by the builders we radioed the necessary information to our office in Paris, which telephoned it on to Chamonix. As soon as the calculations were worked out they were relayed back to us through the same channels. On July 10, less than a week after construction was started, the cable-way successfully made its first lift. In all it was some 2,300 feet long and bridged a difference of over 500 feet in altitude. The cable-way proved entirely adequate for our purpose and all the 43 tons of equipment was lifted without any accident. The usual load was between 1000 and 1500 lbs., but it successfully lifted the 1800 lb. trailers though it took us 36 hours of work to get them up the cliff.

The second stage of the Equipment Trail to Camp III proved more difficult than anticipated. We had planned to winch supplies across the one mile from the top of the cliff to Camp III, but our winch proved defective. The first part of the trail ran round the edge of a small lake, and supplies were carried by our weasels; the next part involved crossing névé and a large moraine, which we managed by the weasels towing the loaded sleds on cables as much as 150 feet long; for the third section from

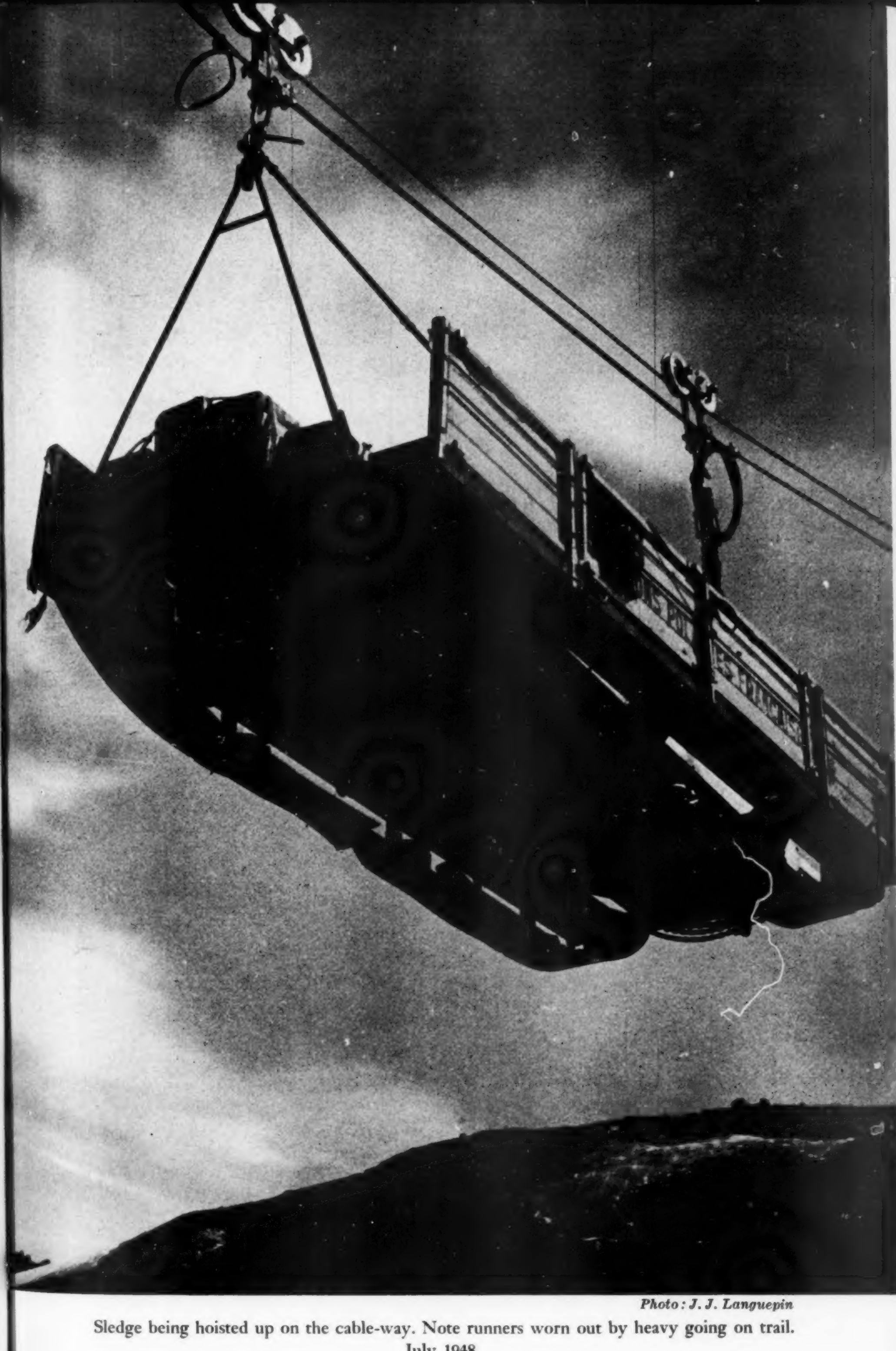


Photo: J. J. Languepin

Sledge being hoisted up on the cable-way. Note runners worn out by heavy going on trail. July 1948.

Photo: J. J. Languepin

The ice cliff at the edge of the Ice Cap, July 1948.

the top of the moraine to the Ice Cap the weasels again carried the supplies. In this manner all the equipment was successfully transported to Camp III.

Meanwhile the first weasel reached the Ice Cap on July 9 and the

Photo: J. J. Languepin

Ice and morainic debris at the edge of the Ice Cap, July 1948.

remainder by July 13. The Weasel Trail crossed very rough and difficult ground but it was of a more temporary nature than the other trails as all the heavy stores were to be carried on the Equipment Trail.

Photo: J. J. Languepin

Stored equipment at Camp III, covered with first autumn snow: Nugssuaq mountains in the background, September 1948.

Camp III

By July 25, after 46 days of work, all the stores had been successfully brought up to Camp III and some 9 miles of trail had been made. The 43 tons carried up had had to be moved by hand as many as fourteen times on the journey.

We were now ready for any reconnaissance work that might be possible on the Ice Cap. A small party had already penetrated some 10 miles inland along the 69°45 N. parallel and had explored the ground between the main areas of crevasses of the Eqip Sermia, the glacier to the north, and the glacier to the south from which the Eqip Kugssua flows.

On July 29 the first convoy reconnaissance of two weasels set off, towing three sledges with 4 tons of equipment. The latter was intended for a station for meteorological, geophysical and glaciological research, which was to be set up on the Ice Cap some distance inland. It was already late in the year and the weather was exceptionally warm. The sledges slipped on the melting surface and overturned frequently, which combined with bad weather and very rough going made progress extremely slow. In 9 hours the convoy only covered 1¼ miles. We therefore decided to set up Camp IIIa at this place.

Camp IIIa

On July 30 the two weasels, towing only one sledge, left Camp IIIa to set up a light meteorological station. The following day they reached a distance of about 10 miles inland from Camp III and were halted by a depression, some ten miles square, cut up by an intricate network of glacial torrents running in canyons up to 45 feet deep. These rivers finally disappeared under the ice. Progress was also rendered more difficult by "cryoconite holes", varying from a few inches to several feet in diameter, caused by the melting into the ice of dust blown inland from the ice-free areas.

After seven days of general reconnaissance work we decided not to continue farther, but to spend the remaining time in research work. Any advance would have required considerable time and might have resulted in serious damage to our equipment. If the 1949 expedition managed to get into the field as early as we hoped, melting would not have started and progress should be much easier.

Storage of equipment

On August 27 the final storage of equipment was started at Camp III. Some of the members were employed dismantling, oiling and packing the equipment in a cache near the camp, while others carried down some 5000 lbs. of scientific instruments and personal possessions to Camp I.

By September 7 the cable-way had been made ready for the winter and we were able to leave Camp III. Packing of stores was already under way at Camp I and we completed this task by September 10.

The twelve days remaining before the arrival of the ship were spent in research work near the coast.

The Norwegian ship *Brandal* arrived on September 22, our 4 tons of equipment were loaded in as little as four hours, and the expedition was able to leave for France. On the way back we put in to Ata, Jakobshavn, Godhavn, Sukkertoppen, Godthaab, Prins Christians Sund and Edinburgh for various scientific reasons. Finally, after five months away, the expedition returned to Rouen on October 13, having accomplished the greater part of all it had set out to do.

THE 1949 EXPEDITION

The main expedition sailed from Rouen on 13 April 1949, aboard the Norwegian freighter *Fjellberg*. Except for a few, whose professional duties prevented them from returning to Greenland, the party included practically all the members of the 1948 expedition. A number of additional technicians and scientists were included, as their services would be necessary for the research work planned during the winter months. In all, the expedition comprised 33 men and 110 tons of stores. Approximately 70 tons of equipment, food, and fuel were left at Keflavik, the main airport of Iceland, to be flown in later.

On June 1, after a delay of three weeks owing to very severe ice conditions, the expedition was able to land the remaining 40 tons of equipment at the same West Coast landing place as in 1948.

We reached the central region of the Greenland Ice Cap on July 17, and at 70°54N., 40°42W., we decided to set up our Central Ice Cap Station, approximately on the same site as Wegener's *Eismitte* of 1931. Forty tons of necessary equipment that could not be parachuted in were carried up by land convoys of weasels towing sledges, and from July 27 to August 5 parachute operations brought to us the 70 tons landed at Keflavik.

The Summer Group, who were to return to France, left the Central Ice Cap Station for the coast on August 24. The eight men of the Winter Group, who remained at the Station, will be isolated for nine months until the return of the Summer Group in 1950. Their main work consists of making weather observations, including radiosonde ascents every second day when possible, and a program of physical research. The meteorological observations are being transmitted four times a day and are channelled into the international network.

In a future number of Arctic we hope to give further information about the work of the 1949 Expedition. Ed.

ICE, OPEN WATER, AND WINTER CLIMATE IN THE EASTERN ARCTIC OF NORTH AMERICA: PART II

By **F. Kenneth Hare and Margaret R. Montgomery**

PART II: THE PATTERN OF WINTER ICE. *By Margaret R. Montgomery*

VERY little information is available on ice conditions in the Arctic seas during the months from October to May. Until recent years, when winter reconnaissance by aircraft became possible, the only records to be found were in the journals of overland travellers or in the logs of ships that had become frozen-in. None of these early observers were able to note conditions over any great distance at one time.

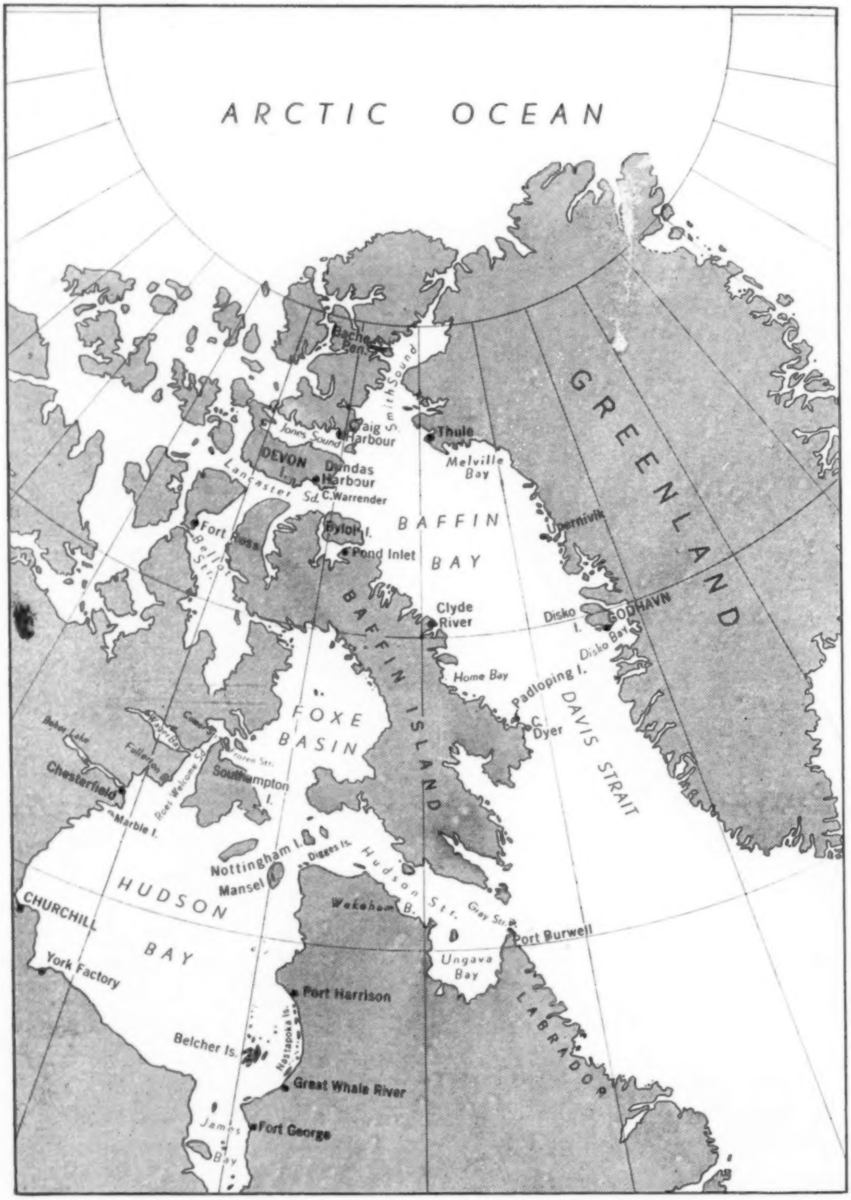
In spite of the many winter flights to Greenland during and since the last war, no reports of the ice conditions observed in Baffin Bay appear to have been published. For this region information is therefore limited to the findings recorded by observers on land and at sea. Ice reconnaissance along Hudson Strait was carried out by the Royal Canadian Air Force during an entire year in 1927-28, and similar observations were made at intervals over Hudson Bay during the winters of 1948 and 1949. The routes followed by these flights are indicated on Fig. 1. The authors have had access to the reports of all these flights and were fortunate in being observers on several of those over Hudson Bay. The photographs taken give an excellent idea of the ice conditions observed.

The following account is a summary of what is known concerning winter conditions in each of the gulfs of warmth discussed in Part I of this paper (*Arctic*, Vol. 2, No. 2, pages 79-89).

Davis Strait and Baffin Bay

A pattern of the ice distribution in Davis Strait and Baffin Bay was familiar to the whalers for over two centuries. Along the Greenland coast they could expect open water as far north as Disko Bay. From there they would work their way north and northwest, skirting the edge of the heavy ice in Melville Bay, and arrive by the end of June in the famous "North Water" between Smith, Jones, and Lancaster Sounds. Whales could usually be expected off Pond Inlet about the second week in July and the whalers would follow them down the coast along the edge of the pack ice as the currents and summer melting cleared the route south. Except for unlucky ships that became frozen-in[1] none of the whalers remained in the Bay after late summer or early autumn. They were all convinced, however, that during the winter the Greenland coast remained open possibly

[1]Smith, Charles Edward, 'From the Deep of the Sea', 1922. An account of the experiences of the whaling ship *Diana*, which became frozen-in in Baffin Bay in 1866.



as far north as Disko Island, that the North Water was never ice-bound, and that the shelf of pack ice against the east Baffin coast was impenetrable and of considerable width. From the information available at present this appears to be a fairly accurate picture.

Ice may form at the head of the south Greenland fjords in November or December but the marine approaches along the south and west coasts remain open until the heavy east-coast ice arrives in January or February. By the end of March this stream has reached its maximum extent in Baffin Bay. In the early winter months open water may reach as far north as the Melville Bay area and Mr. A. E. Porsild[2] has recently reminded us that

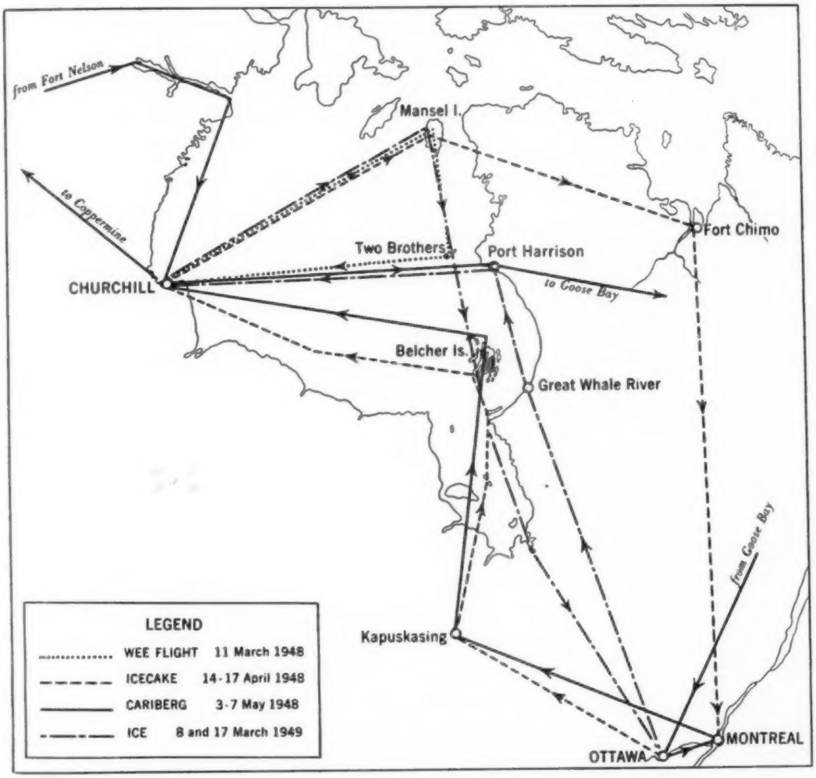


Fig. 1. Routes of ice reconnaissance flights in the winters of 1947-8 and 1948-9.

at Upernivik, nearly 73°N. latitude, cargo ships were able to unload during the Christmas week in 1942. Even when the great stream of east-coast ice moves round the tip of Greenland and up the west coast there is usually a belt of open water or loose pack between it and the heavy ice off Baffin Island.

As with other climatic phenomena there may be considerable annual variation in the amount and date of arrival of this heavy ice. During the past winter, navigation off the Greenland coast as far north as the Arctic

[2]Porsild, A. E., "The changing climate of the Arctic". *Arctic Circular* 2 (1949) p. 4.

Circle was completely ice-free even late in February. Those who were in the area are of the opinion that open water extended much farther north but that its width from the coast became rapidly narrower. This agrees very well with the *Arctic Pilot*:[3] "Between Disko bugt and Upernivik . . . the West ice is usually visible during the whole winter, and sometimes approaches the coast and freezes together with the winter ice."

Present information is not sufficient to allow us to determine if a belt of open water or loose ice extends northwesterly across Baffin Bay to Lancaster Sound. It is, however, generally recognized that there is always an ice-free area in the North Water off Smith and Lancaster Sounds. Even in the worst ice years, sailing ships such as the *Diana*[4] could always count on open water in this area. According to Dr. M. J. Dunbar[5] it is the opinion of the natives that Lancaster Sound never freezes over, or at least not solidly enough to be safe for travel. This was also the conclusion reached by the *Marion* Expedition in 1928.[6] That expedition reported that "Lancaster Sound is, however, occasionally frozen solidly from shore to shore, but at such times even the natives deem any attempt to cross to North Devon an extremely hazardous undertaking because a sudden shift of the winds or the currents may break the bridge. The neighbourhood of Cape Warrander on Lancaster Sound is said to have more open water than any other locality in Baffin Bay."

On Baffin Island the stretch between Lancaster Sound and Cape Dyer has been described as the most unexplored region of the east coast because of its barrier of ice, floe and pack. South of Cape Dyer tides and currents limit the seaward growth of the ice shelf, but north of this, shoals and coastal islands favour a wide ledge of shore ice. Against this land floe the thick, hard, heavy pack is piled up by the current. Even in July and August the *Marion* in 1928 was unable to penetrate closer than within 36 miles of the coast off Cape Dyer.[7] Dr. Boas[8] has estimated that between Bylot Island and Cape Dyer, notably off the Home Bay area, the width of the ice shelf in winter averages about 80 miles. This ice is in general rough and hummocked, with smooth surfaces only in the sheltered bays. Beyond this, there is an almost 100% cover of pack ice.

In February of 1949 some observations were made along the eastern border of this ice edge in the vicinity of 65° North and 57° West. The pack became increasingly heavy as the ship tried to force a passage

[3]*Arctic Pilot*, vol. III, 4th ed., 1947, pp. 160-61. cf. also 'The Marion Expedition to Davis Strait and Baffin Bay, 1928'. Scientific Results, Part III, Washington, 1931, p. 44.

[4]Smith, Charles Edward, op. cit.

[5]Personal letter from McGill University, dated 9 February 1949.

[6]'The Marion Expedition to Davis Strait and Baffin Bay, 1928'. Scientific Results, Part III, Washington, 1931, p. 44.

[7]Ibid, Scientific Results, Part I, Washington, 1932, p. 30.

[8]Boas, F., "The Central Eskimo", *Ann. Rep. Smithsonian Inst. Bur. Ethnology*, 6 (1884-5) p. 417.

westward. It was felt that a strongly built ship with icebreaker escort might on occasion be able to get through the outer fringe of this pack even when its ice cover was as much as 70% to 80%. It was considered doubtful if even an icebreaker could penetrate much farther under conditions of greater coverage.

A review of available information of winter conditions in Baffin Bay, therefore, shows open water extending along the Greenland coast, narrowing as it goes northward and reaching its minimum width about the month of March. Northwest, in the vicinity of Lancaster Sound, open water may be expected in all seasons. East Baffin as far south as Cape Dyer is blocked during the winter months by heavy ice which extends far over to the Greenland coast.

Hudson Strait

It is the unanimous opinion of those who have had experience in the area, that Hudson Strait never completely freezes over. Though the disposition and amount of ice may vary from place to place, from month to month and from year to year, there appears to be no record of the channel having been blocked solidly by ice throughout its entire length at the same time.

The outstanding explorers of this region such as A. P. Low[9] and Robert Bell[10] have stressed this point of view. At the Select Committee of the House of Commons in 1884, various Hudson's Bay Company officials pointed out that Eskimo from Baffin Island could only cross to the mainland trading posts on the south side of Hudson Strait about once in every ten years. Even then the crossings were always made at different places along the coast and never over solid ice but across floating pans. The Honourable W. J. Christie, testifying before this Committee[11] stated that in his experience along the Strait he had frequently seen sea smoke rising far out in the channel during the winter months. To natives and whites alike this sign was an indication of the presence of open water.

In 1927-28 the Dominion Government sent an expedition under N. B. McLean[12] to report on ice conditions during the whole year. Three stations were set up, one at Nottingham Island at the western entrance, one at Wakeham Bay in the centre, and one at Port Burwell at the eastern approaches. In addition to observations made from the shore, each base had R.C.A.F. air support and flew regular sorties over the channel. The report of this expedition is the most complete and extensive ice survey

[9]Low, A. P., 'The cruise of the *Neptune*', Ottawa, 1906, p. 292.

[10]Report of the Select Committee of the House of Commons (Canada) on "The question of the navigation of Hudson's Bay", Ottawa, 1884, p. 5.

[11]Ibid., p. 39.

[12]'Report of the Hudson Strait Expedition, 1927-28'. Dept. of Marine and Fisheries, Ottawa, 1929.

made in the Canadian Arctic. It also confirmed the report of an earlier Hudson Strait expedition under Wakeham in 1897 that the Strait is never completely closed.

In the fall, winter ice appears first in the western end of the Strait. It usually forms late in October or early in November. From then on until some time in the third week of April the shelf of fast ice around the islands in this area varies from between two to five miles. Along the coast of northwest Quebec, the land-fast ice rarely exceeds two miles in width except in the very sheltered bays. The extent of pack ice cover is greater near the western entrance than elsewhere in the straits and may vary from 50% to 95%. From the end of January to the end of May it usually averages at least 80% to 85%. This is, however, not a static condition and may change entirely from one day to the next as the ice is driven by the wind or as leads open up stretches of ice-free water. These leads may be long or short and vary from half a mile to 10 miles in width.

In the central area of the Strait off Wakeham Bay, ice forms along the coast by early November and may grow to a thickness of nearly four feet during the winter.[13] Ice in mid channel appears late in November or early December. Although periodically the area may be almost entirely covered with heavy pack, the total ice cover during any season is less complete here than at the western end. As a rule the period of closest pack occurs between the end of January and the middle of March. The ice by that time has become heavily rafted through the action of wind and tide.

Around Port Burwell ice forms along the coast in November but is liable to be constantly broken up by wind and tide and may not become solid until late in that month or even in December. When it does, it quickly grows to a depth of 20 inches or more. Thick fields of floe ice from Baffin Bay may block the channel for several days and then clear away leaving less than a 50% cover in the area. Along the eastern edge of Ungava Bay where the water is shallow, a shelf of fast ice extends out for about 8 miles. Beyond this, however, the ice never appears to consolidate and usually varies between a 60% and 80% cover. From January onwards the amount of ice in the entrance of the Strait may range from nothing to 95% or 100% depending on whether or not thick fields of Baffin Bay ice are in the vicinity.

Deep channels, such as Gray Strait north of Port Burwell and the area south of Digges Islands at the western end of Hudson Strait, are practically never covered even with loose pack during the winter months as their strong currents keep them clear. In the spring, when the ice

[13] 'Report of the Expedition to Hudson's Bay and Cumberland Gulf', under the command of William Wakeham in 1897. Dept. of Marine and Fisheries, Ottawa, 1898.

begins to run freely from Foxe Basin, these channels are usually choked while the surrounding areas gradually become ice-free.

The observations of the 1927-28 expedition confirmed earlier reports of winter ice conditions in Hudson Strait.[14] The ice forms first in the west, becomes closely packed there and for months at a time is so jammed that no open water is visible from Southampton Island to beyond Nottingham Island. Elsewhere in the Strait the amount and extent of ice cover shows great variation with place and time. In general however, during the winter months it tends to decrease as one goes eastward. North of Port Burwell conditions are greatly dependent on the flow of ice from Baffin Bay.

Hudson Bay

Until recently it was generally accepted that the central part of Hudson Bay never freezes over. This opinion has persisted for many years even among explorers and scientists familiar with the region.[15] A. P. Low in his report of 'The cruise of the *Neptune*', (1906, p. 292) states that "The main body of Hudson bay does not freeze solid, and the same may be said of Hudson strait." He adds that "Although this is the case, these waters are quite unnavigable for ordinary ships during the winter and spring months owing to the great sheets of heavy ice borne backwards and forwards by the tides and currents". . . . Similarly the *Arctic Pilot*[16] states "In general the ice is about 3 to 4 feet . . . in thickness, and extends off the east shore for 60 or 70 miles to include the islands" while "in the remainder of the bay [it extends only] from one to 5 miles. During the winter this shore ice is broken up from time to time by gales into large floes." Such opinions were constantly repeated by those who gave evidence to the House of Commons Committee on "The question of the navigation of Hudson's Bay" in 1884.[17]

Recent R.C.A.F. reconnaissance flights during the winter months of 1948 and 1949 have shown a very different picture. Around the edge of the Bay is a shelf of land-fast ice which varies in width according to the depth of water, the outline of the coast, and the general configuration of the bottom. Beyond this fast ice usually lies the open water of the shore lead or a stretch of brash ice. According to the direction of the wind this area varies in width anywhere from about a mile or a mile and a half to 30 or 40 nautical miles across. Beyond this, the centre of the Bay is frozen solid.

[14]'Report of the second Hudson's Bay Expedition', under the command of Lieut. A. R. Gordon, 1885. Dept. of Marine and Fisheries, Ottawa, 1898.

[15]Although it became known during the war, as a result of air activity in the winter, that large parts of Hudson Bay were frozen over, no systematic work had been done to determine the extent or date of this cover.

[16]*Arctic Pilot*, vol. III, 4th ed., 1947, p. 54.

[17]Report of the Select Committee of the House of Commons, op. cit.

Photo: R.C.A.F.

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Photo: R.C.A

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Photo: R.C.A.F.

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Photo: R.C.

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Vertical photographs taken at 20-minute intervals across Hudson Bay between Port Harrison and Churchill on 8 March 1949.

Photo: R.C.A.F.

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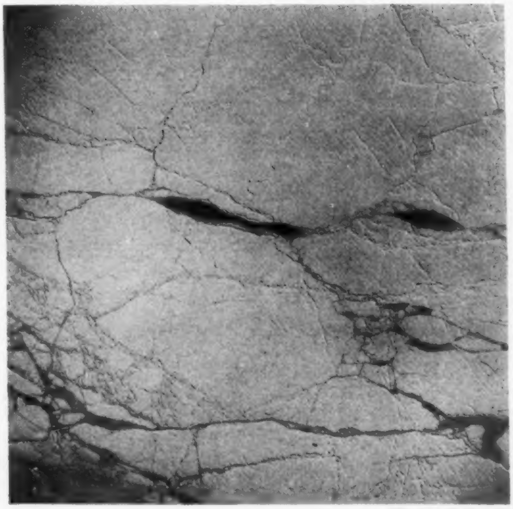

Photo: R.C.A.F.

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Photo: R.C.A.F.

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Photo: R.C.A.F.

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Vertical photographs taken at 20-minute intervals across Hudson Bay between Port Harrison and Churchill on 8 March 1949.

Photo: R.C.A.F.
Windswept surface of close pack ice towards the centre of Hudson Bay, 6 May 1948.

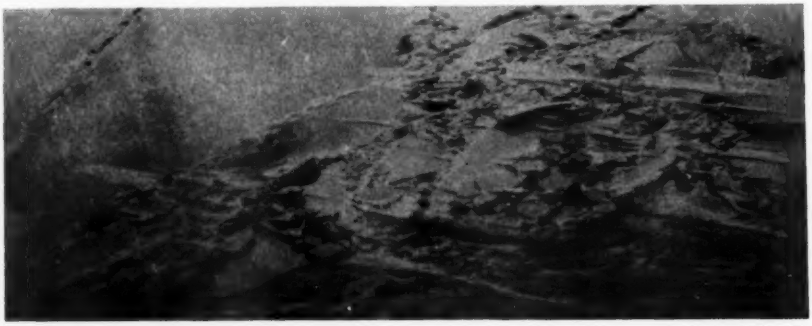


Photo: R.C.A.F.
Detail of rafted ice in central area of Hudson Bay, 6 May 1948.

Photographs taken in the early spring months of 1948[18] when the snow cover was disappearing along the floe edge show that this solid ice sheet over the centre of the Bay is formed originally of large and small pans which may have broken-up many times in the course of the winter. These become rafted together, refrozen into a single sheet and covered over during the winter by a heavy layer of packed and driven snow. Pressure ridges containing ice blocks 5 or 10 feet thick criss-cross the surface in all directions and may rise to heights of 15 or 30 feet. Leads

[18]The "Cariberg" flight, 3-7 May 1948,—R.C.A.F.

Photo: R.C.A.F.

Pressure ridges west of Port Harrison from an altitude of about 150 ft., 8 March 1949.

from several feet to several miles in width are constantly opening up under the pressure of the ice and refreezing or closing again when the direction of pressure changes. Whether or not there is any consistent direction to these leads and pressure ridges has not yet been determined.

From the observations to date, it would seem that there is a tendency for the leads and ridges near the edge of the Bay to parallel the direction of the shore lead. Farther out the direction seems to change with the changing stresses of wind and tide. It is quite easy from an aircraft to trace the lines of old refrozen leads, often running at an angle to the present open lanes. The same is true for the network of pressure ridges although these ridges may at times be practically absent in the area immediately beyond the shore lead. A preliminary report on operation "Ice-Cake"[19], April 1948, notes that "there were very few pressure ridges for about 80 miles out of Churchill. They started as a very fine open lacy pattern and increased moderately in size and number". The maximum was reached about two-thirds of the way to Mansel Island, but at no time were the ridges as large or as numerous as those seen opposite the Nelson River.

[19]Leggett, R. F., and Nazzer, D. B., "Snow and ice conditions in Northern Canada, spring, 1948". Nat. Res. Council, Ass. Comm. on Soil and Snow Mechanics, Tech. Mem. 12, Ottawa.

The shore lead, which seems to have caused so much confusion in estimating the ice cover of Hudson Bay, may at times be entirely absent. Along the east coast from Great Whale River to Port Harrison the "Ice" reconnaissance of 8 March 1949 found no suggestion of open water. There were traces of old refrozen leads but none of them as large or as continuous as the one found along this same coast by the "Cariberg" reconnaissance of 6 May 1948. At that time the lane of open water off Port Harrison was 25 to 30 miles wide and seemed to stretch north and south along the coast as far as could be seen. It should be noted that this wide shore lead resulted after several days of NE winds which had effectively driven the ice offshore. A month previously when the "Ice-Cake" flight had covered this same area there had been a westerly wind for several days and at that time there was no sign of open water along the east coast. Open water was however seen around Mansel Island—possibly the result of wind, tide and strong current.

It would be of interest to know whether any open water exists to the west of the Belcher Islands at times when there is no lead along the Quebec coast. If there is, it would suggest that under certain conditions the "shore lead" merely moves west beyond the protecting fringe of islands and out towards deeper water. This possibility is further strengthened by the observation of R. J. Flaherty[20] (quoted in the *Arctic Pilot*) that "The climate of the islands differs widely from that of the opposite mainland. Compared with weather reports from Great Whale River for the same period . . . [the islands had] a far greater proportion of overcast skies and fogs, stronger and more constant winds, but higher and more equable temperatures."

On the west and northwest coast where most observations of ice conditions have been made, the shore lead is more persistent than on the east coast. The explanation of this would appear to be the predominance of west and northwest winds in this area. Each time an ice reconnaissance has been made there has always been some indication of open water along this edge of the Bay.

There have as yet been no aerial reconnaissances in the late fall and early winter to observe the time of freeze-up. It is therefore possible only to repeat what has already been said by travellers and explorers in the region. There seems to be general agreement that along the coast the ice may form in the shallow bays early in November and in the mouths of rivers by the end of the month. In his journey to the Nastapoka Islands in 1910 R. J. Flaherty[21] records that he was forced to wait at Fort George on the mainland until December before the Bay ice was solid

[20]Flaherty, R. J., "The Belcher Islands of Hudson Bay: their discovery and exploration". *Geogr. Rev.* 5 (1918) p. 453.

[21]Ibid., p. 436.

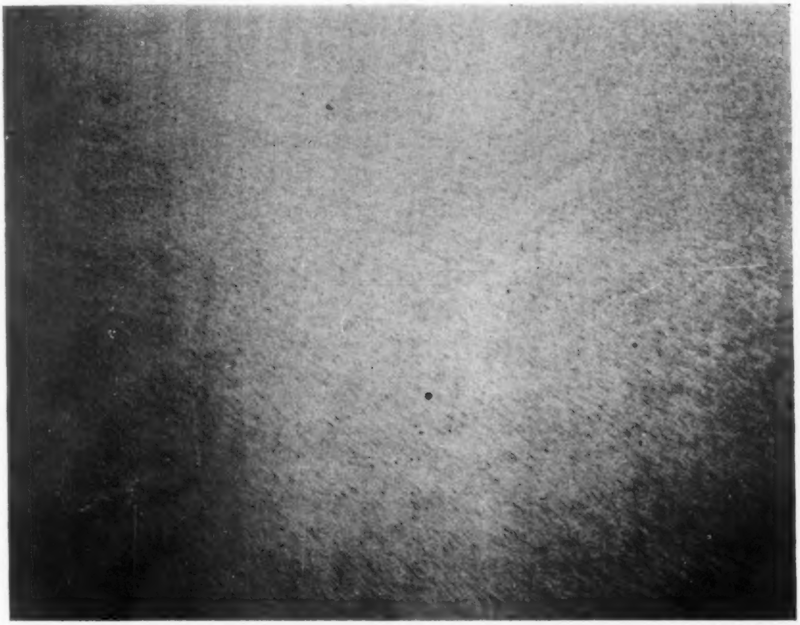


Photo: R.C.A.F.

Smooth ice, approximately 10 miles south of Churchill, 17 March 1949.

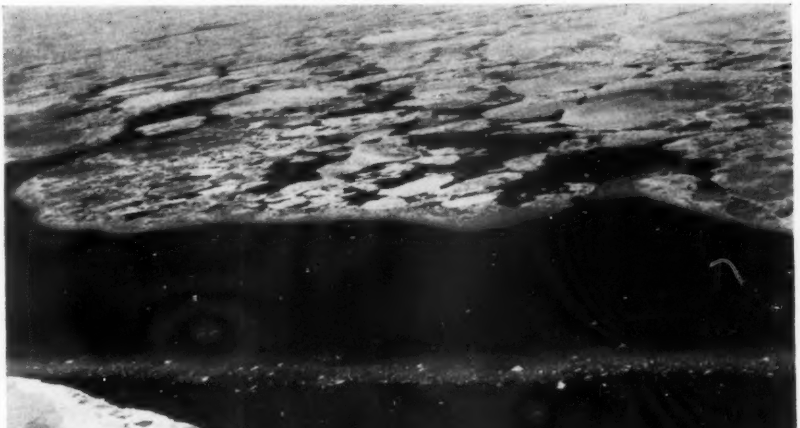


Photo: R.C.A.F.

Shore ice, shore lead, with floating pans along edge of Bay ice and streak of brash ice in foreground, west coast Hudson Bay near Eskimo Point, 6 May 1948.

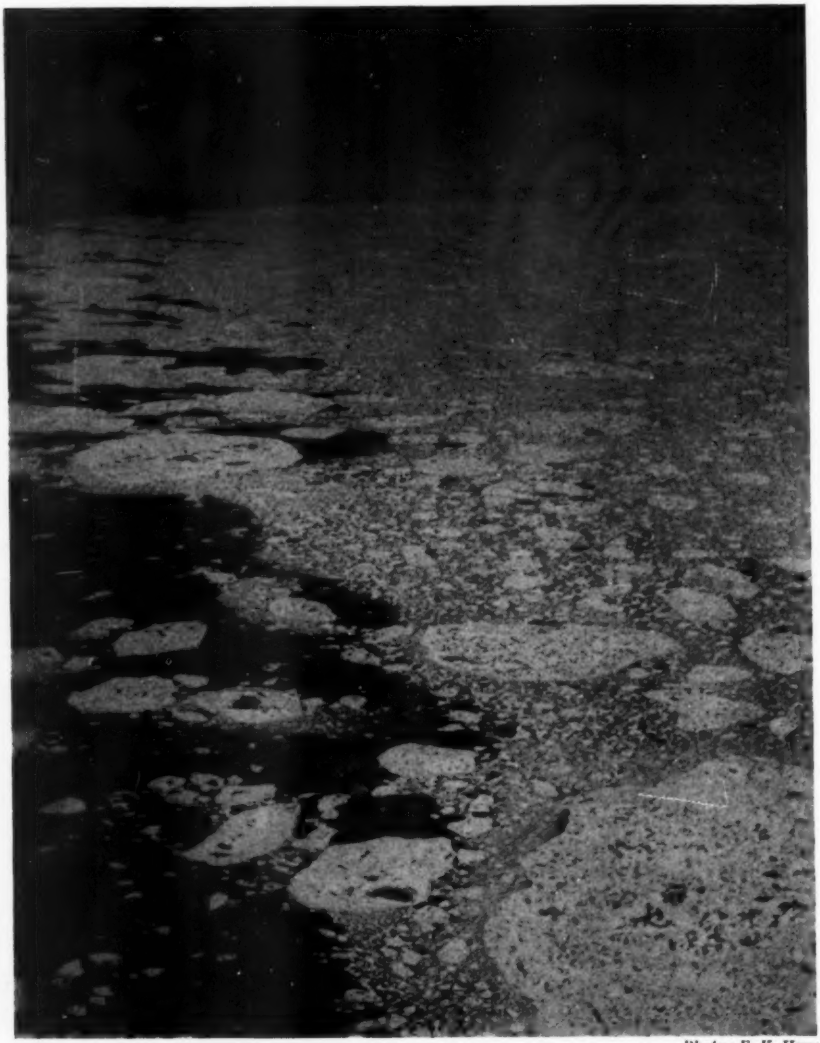


Photo: F. K. Hare

Brash ice along edge of James Bay, 5 May 1948.

enough for safe travel. He also found that February to March was the best time for a crossing from the mainland to the Belcher Islands.[22] In the far northern part the small bays freeze over early in October[23] or early in November.[24] As the centre of the Bay would freeze somewhat later than

[22]Flaherty, R. J., op. cit., p. 441.

[23]Low, A. P., op. cit., p. 292.

[24]Birket-Smith, Kaj, "Geographical Notes on The Barren Grounds". Rep. Fifth Thule Exped., 1921-24. Copenhagen, 1933. Vol. I, No. 4, p. 74.

the coastal regions, these dates seem to fit very closely with the time suggested by the temperature charts for the consolidation of ice cover over the whole area. It is hoped that the ice observations planned for the fall and winter of 1949-50 will give further evidence justifying this conclusion.

Most existing reports assume that James Bay is frozen from shore to shore all winter. On all flights of this series, however, it was found to have a high percentage of open water which at times extended as far north as the Belcher Islands. Apart from the shelf of shore ice and ice bridges between the islands in the southern part, the greatest amount of ice seen in this area was in the form of loose, floating pans.

The findings of the aerial reconnaissance flights agree very closely with the conclusions already drawn from a study of the temperature charts (see Part I of this paper). The question not unnaturally arises: Why then were the earlier explorers so convinced that the central part of Hudson Bay remains largely ice-free? A possible explanation may lie in the fact that there is no record of anyone having attempted to cross the Bay in winter. Travellers in the area always tried to make for harbour by the end of September or beginning of October. There they became frozen-in and were separated from the shore lead by some miles of fast ice. Sea smoke from the lead would suggest open water out towards the centre of the Bay and this belief would seem all the more likely at times when the lead was several miles wide. In fact the Honourable W. J. Christie of the North-West Council in his evidence before the Parliamentary Committee, 1884,[25] gave this very reason as the basis for his opinion. He stated, "I do not think . . . Hudson's Bay is frozen over, except a certain distance out from the shore, as vapor and fog is seen rising from the open water beyond the frozen shore ice, both at York and Churchill."

Furthermore the shore lead can be very wide. The one off Port Harrison in May 1948 was more than 28 miles across and pilots flying out from Churchill report that leads 10 miles wide are not uncommon on the western side of the Bay. From the low elevations of the coast such a stretch of water beyond the land floe would certainly give grounds for believing there was no ice further out. Pilots flying from Churchill to Chesterfield Inlet have had the experience of seeing open water to the horizon at Churchill, only to discover when they are in the air that it was merely the wide shore lead and that there was solid ice beyond.

A further reason is that those who wintered in the Bay usually did so in the northern parts. Low wintered at Fullerton Bay and put into harbour on September 23. The New Bedford[26] whalers were unanimous that "Hudson's Bay is open all winter, and what little ice makes on the shore

[25]Report of the Select Committee of the House of Commons, op. cit., p. 33.
[26]Ibid., p. 25.

breaks up with every gale of wind." But they never attempted to cross the Bay during the winter and always put into Marble Island early in the fall. This northern section has perhaps a higher percentage of open water than any other part of the Bay because of the strong currents from Foxe Basin and the upwelling along the coast. Kaj Birket-Smith[27] in the 'Report of the Fifth Thule Expedition' says "Even in the rather narrow Roe's Welcome, however, it is only exceptionally that the ice lies firm over to Southampton Island. . . . In Wager Bay there are two places where, owing to the current, it never freezes over, one at the mouth, the other a little way in at the Narrows. In Chesterfield Inlet, too, there is unsafe ice or current openings, and at the outlet of Baker Lake lies the great current opening called Morjunitjuaq, which, when we were in the country, had only been covered over once in the memory of man, viz. in 1918." Therkel Mathiassen[28] adds to this list of open water areas by including Frozen and Comer Straits around Southampton Island.

With so much open water in the vicinity it is hardly surprising that those who wintered in this northern area were convinced that the Bay remained open. It is worth noting, too, that most of our information about winter conditions over the Bay came from the explorers and whalers who had remained on the west and northern coast from fall until spring.

General Conclusion

As shown in Part I of this paper, open water surfaces in the Arctic reveal themselves by their modifying effect on surrounding temperatures. The absence of such modification during the winter may therefore be taken as an indication that the neighbouring water surfaces are frozen-over. Part II has shown that this hypothesis is supported by the existing scanty records for the Baffin Bay and Hudson Strait areas, but until more complete photographic records are available, further correlation is not possible.

In Hudson Bay the ice conditions inferred from the meteorological evidence and observed on reconnaissance flights contradict previous reports. The authors feel that these reports based on shore observations only are in error. Aerial photographs show that the Bay was completely ice-covered in the winters of 1947-8 and 1948-9, and although two winters alone cannot establish that this is always the case it should be stressed that temperatures throughout these particular winters as a whole are recorded as being normal. Extensive reconnaissance over a period of years will be necessary in order to establish beyond dispute the details of ice conditions in the area. Plans for such observations have already been completed for the winter of 1949-50.

[27]Birket-Smith, Kaj., op. cit., pp. 74-5 (cf. also Boas, F., op. cit., p. 418).

[28]Mathiassen, Therkel, "Contributions to the physiography of Southampton Island". Rep. Fifth Thule Exped., 1921-24. Copenhagen, 1931. Vol. 1, No. 1, p. 22.

Photo: T. L. Tanton

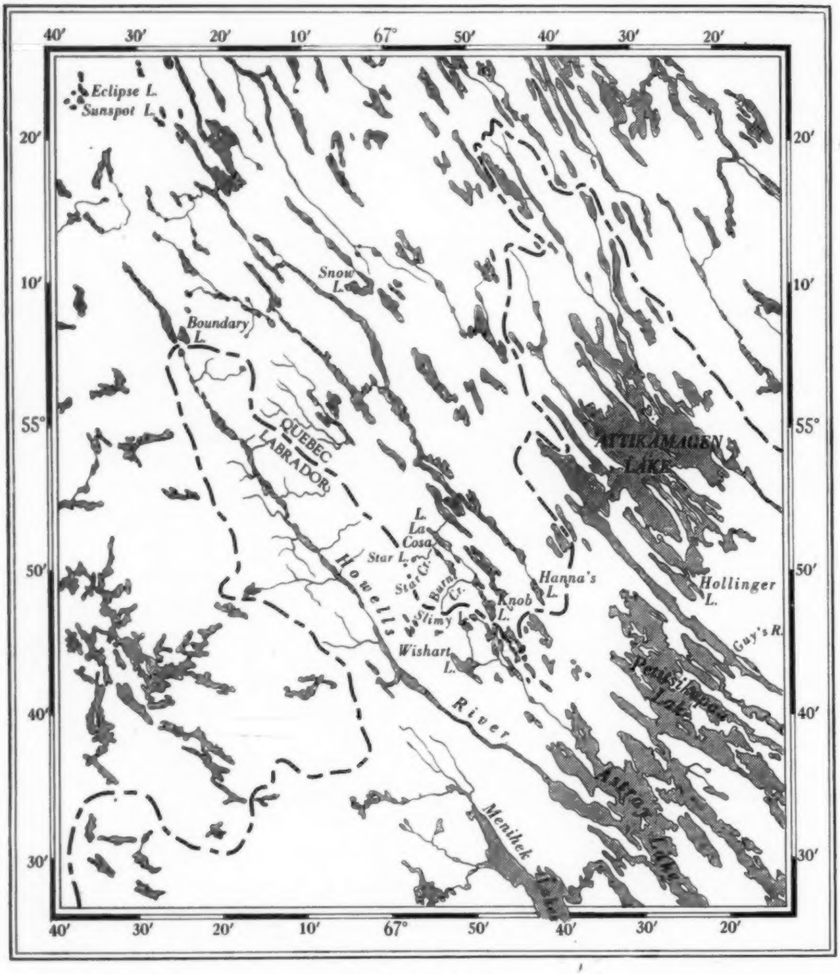
Fishing in Wishart Lake: in foreground 12 lb. lake trout.

NOTES ON FISH OF THE INTERIOR OF THE LABRADOR PENINSULA

By Eugene G. Munroe

A visitor to the interior of the Labrador Peninsula familiar only with the fauna of our depleted southern waters cannot fail to be impressed by the enormous abundance of food and game fish. The writer, under the auspices of the Defence Research Board of Canada, was able to spend about six weeks in biological work during the summer of 1948, in the Knob Lake region, situated at approximately 55°N., 67°W., on the Quebec-Labrador boundary. While the main objectives of the trip were not ichthyological, it was possible to make some observations on the fishes of the region. Notes on the various species will be given, followed by a brief discussion of the general features of the lakes and streams and economic considerations.

Detailed acknowledgment has been made elsewhere of the assistance from several quarters without which the expedition would have been impossible or scientifically unprofitable. The writer would like to repeat at this time, however, his indebtedness not only to the Defence Research Board for financial and other support, and to the Division of Entomology, Science Service, Department of Agriculture, for supplying technical equipment and advice, but also to the Labrador Mining and Exploration Company for providing accommodation, transport facilities, and general



Knob Lake district.

assistance at their base at Burnt Creek. The personnel of this Company were uniformly helpful and informative. Their knowledge of biological conditions was extensive and proved as far as it could be checked to be unusually accurate; the information which they supplied was consequently of the greatest value in guiding and supplementing the writer's observations.

Notes on the Species

Speckled trout (*Salvelinus fontinalis*)

This is the most abundant and the most widely distributed of the food and game fishes of the region. Speckled trout exist in very large

numbers in almost all of the lakes and in many of the streams of the area. In a favourable spot on an average lake almost every cast will result in the hooking of at least one fish. Although the abundance of the fish is general, their size varies noticeably from lake to lake. In almost every lake there seems to be a fairly definite upper size limit, which is reached or approached by a considerable proportion of the individuals at one time. Catches of trout from a single source, therefore, tend to be remarkably uniform in size, and show some correlation with the size of the lake. There are wide departures from this rule, however, and four- or five-pound trout can be obtained in numbers from some quite small lakes. In certain minute, bog-rimmed lakes the largest fish are about 6 inches in length, and individuals from 4 inches up are sexually mature. On the other hand, in the great lowland lakes of the Hamilton drainage three- to five-pound trout are common, and a specimen weighing 11½ pounds is said to have been taken.

The abundance of speckled trout in the Hamilton drainage on the Labrador side of the boundary appears to be about the same as in the northern Koksoak drainage in Quebec. Conditions are very similar in these two drainages, and trout-bearing lakes in the two systems are often separated by only a few hundred yards of land. In addition to the difference in size of fish from different lakes, there is also considerable colour variation, and it is likely that this is to some extent correlated with drainage system. Trout from the Hamilton drainage seemed on the average to be more heavily pigmented and to have a more extensive red breeding flush than those from the northern drainage, which were paler and more silvery, approaching the common form of the southern Laurentians. Material was not seen from a sufficient variety of localities, however, to establish this. The spawning time in this region is reported to be after the middle of October, immediately before the freezing over of the lakes.

The speckled trout examined were heavily parasitized, the gut and body cavity containing very large numbers of tapeworms and roundworms. The fish however were mostly fat and in good condition and the flesh appeared to be quite sound; most or all of the worms being removed in the normal process of cleaning.

A representative collection of worms was made, and is being studied by the writer's colleague at the Institute of Parasitology, Macdonald College, Dr. L. P. E. Choquette. Dr. Choquette's preliminary examination indicates that the worms were mainly of the following four types:

Cestoda	*Proteocephalus* sp.	adults
	Eubothrium sp.	plerocercoid larvae
Nematoda	*Philonema* sp.	adults
Acanthocephala	*Echinorhynchus* sp.	adults

Photo: T. L. Tanton

Burnt Creek Settlement, looking southwest.

The distribution of speckled trout is general except in certain minor upland waters, such as the upper Burnt Creek system, which are barred to them by waterfalls. Specific records were obtained from the following localities:

Hamilton drainage:	Wishart Lake[1]	Northern drainage:	Hanna's Lake
	Slimy Lake		Knob Lake
	Guy's River		Star Lake
			Star Creek
			Lac La Cosa (Key Lake)
			Snow Lake
			Eclipse Lake

No Quebec red trout (*Salvelinus marstoni*) or Arctic char (*S. alpinus*) were seen or reliably reported.

Lake trout (*Cristivomer namaycush*)

Like the speckled trout, the lake trout is widely distributed and abundant. It is restricted to the larger lakes, roughly speaking those more than a mile in length, so that the actual number of localities where it occurs is considerably smaller. It makes up in abundance for its restricted distribution: a party of three or four men can count on taking

[1]Many of the place-names given in this paper are those used by the mining companies and have not been officially adopted by the Board on Geographical Names.

enough lake trout in a day to provide four meals for 120 mining personnel. The average weight of the fish captured is between five and ten pounds, but individuals up to 30 pounds have been reported. The mean size is thus somewhat smaller than in parts of western Canada. The total weight produced by each lake must, however, be enormous, and it is interesting that these numbers of lake trout can exist with equally massive populations of speckled trout, apparently without serious detriment to either species.

The lake trout are said to spawn in this region in about the first half of September. A single specimen collected for examination proved to be free of visceral or external parasites.

The following specific locality records were obtained:

Hamilton drainage:	Wishart Lake	Northern drainage:	Boundary Lake
	Guy's River		Sunspot Lake
			Hanna's Lake

Ouananiche or land-locked salmon (*Salmo salar ouananiche* or a similar subspecies)

The distribution of this fish appears to be much more extensive than has usually been realized. A specimen was seen from Guy's River, and Dr. J. A. Retty, of the Hollinger North Shore Exploration Company, states that he has seen it from the Menihek Lakes, also on the Hamilton drainage, and from unspecified waters on the Northern Drainage, well north of the height of land. It is quite possible that more than one colonization from the sea is represented, and without further investigation it would be rash to say that the populations from these various localities are subspecifically identical, either with one another or with the true ouananiche of Lake St. John.

Although they are widely distributed, land-locked salmon appear to be rare in this region. They are superb game fish: the Guy's River specimen, which weighed perhaps a pound and a half, was said to have outfought several three- or four-pound speckled trout taken on the same day. No data are available on the spawning of this form. The single specimen examined was free of internal or external parasites.

Whitefish (*Coregonus* sp.)

Whitefish have been taken in Knob Lake, and are doubtless well distributed in the larger lakes. They are not caught frequently, but this may be the result of unsuitable angling methods rather than actual scarcity. They are said to rise to the hook and line only at spawning time, which is around October 15. No specimens were seen.

Pike (*Esox ?lucius*)

Pike are said to occur in several of the larger lakes in the immediate vicinity of Knob Lake. No specimens were seen, but the fish reported

Photo: T. L. Tanton

Knob Lake, looking south. The knob south of the lake can be seen on the skyline.

is certainly an *Esox* and most probably the great northern pike, *E. lucius.* No weights or spawning data are available. Specific locality records are:

Northern drainage: Hanna's Lake
Lac La Cosa (Key Lake)

Suckers and minnows (Catostomidae and Cyprinidae)

These fish, called indiscriminately "suckers" in local parlance, are extremely numerous in the Knob Lake area, but since they have little game value and are not used for food it is hard to get accurate information about them. At least four forms are said to be present, but it is possible that the differences are in part owing to age or sex. General descriptions of two of these forms were obtained:

(1) "Common sucker" (possibly *Catostomus commersonii*). Described as being rather pale above and silvery below, with large scales and a "sucker mouth". Spawns in streams about June 15. Recorded from Hanna's Lake.

(2) "Sturgeon sucker" (evidently not *Catostomus catostomus,* and probably a Cyprinid). Described as being very dark above, with small scales and a blood red dorso-lateral stripe. The head is elongate and

"sturgeon-like" and the mouth resembles that of a whitefish. Large numbers of this species swim upstream in Knob Creek at spawning time, which is also about the middle of June.

General Features of the Lakes and Streams

An outstanding feature of this region is the number and variety of its aquatic habitats. About twenty per cent of the area of the Dyke Lake sheet of the 8 mile to the 1 inch map is shown as water, and many of the smaller bodies of water are not mapped. There is every transition from small temporary ponds to lakes larger than Lake St. John; similarly, streams range in size from small seepage- or snow-fed rivulets up to large, rapid rivers such as Howells River.

The lakes are for the most part shallow and linear in structure. The proportion of shoreline and of shallow water is unusually high, which contributes to the great biological productivity. The water is in general greenish in colour and some of the lakes are surprisingly clear.

The composition of the aquatic macrofauna suggests that insects form a very large part of the basic food supply of the fish population. In lakes the most numerous insects are the larvae of caddis flies (Trichoptera) and of midges (Chironomidae, etc.), and both larvae and adults of water beetles of various families. In the more rapid streams the larvae of Blepharoceridae and of blackflies (Simuliidae) and the nymphs of stone flies (Plecoptera) are also abundant. Mayflies (Ephemerida) and dragon flies (Odonata), important sources of fish food in more southern waters, occur only in small numbers in the Knob Lake district.

Generally speaking, lakes much under half a mile in length do not contain any significant quantity of fish, other than small speckled trout. Lakes from one half to two miles in length produce large numbers of speckled trout, and in some cases large individual fish. In lakes approaching two miles in length, numbers of lake trout and some whitefish and pike may be found, in addition to the speckled trout. The land-locked salmon has so far been recorded only from very large lakes and their tributary streams.

The small streams may contain considerable numbers of speckled trout in summer, but they are almost or quite frozen in the winter, and must apparently be restocked each year by the migration of fish from connecting lakes. The larger rivers such as Howells River may have a permanent fish fauna, but no information as to its composition is available.

The open season for most lakes is short, the ice breaking up in June

and re-forming in October. In view of this the very large weight of fish maintained is remarkable.

Economic Considerations

The economic potentialities of such an enormous reservoir of food and game fishes are obvious. From the standpoint of the angler, the main difficulty is perhaps the superabundance of trout. The discriminating fisherman will soon tire of a pool where almost every cast brings out one or two sizable fish, regardless of the type of lure used. However, speckled trout of four pounds or more, such as are regularly taken in some localities, are not to be treated with contempt, while the land-locked salmon, when its distribution becomes better known, will add enormously to the sporting potentialities of the region.

Economically there is a very large supply of fish in this area which is quite suitable for food, and a large part of which is in the delicacy class. Thus, for instance, from Star Lake, a roughly circular lake about half a mile in diameter, situated not far from Burnt Creek, an estimated 100 speckled trout a week have been withdrawn during the ice-free season for the three years from 1946 to 1948, without any apparent decrease in the numbers or the average weight of the fish. The annual withdrawal may be estimated conservatively at 800 pounds. This lake is fished because of proximity to the mining camps rather than because of abundance of fish, and a much greater weight of fish can be taken with the same expenditure of time in the larger lakes where lake trout are also present. When it is considered that there are approximately 4500 square miles of water in the area of the Dyke Lake sheet of the 8 mile to the 1 inch map alone, the enormous fish populations that exist in this area can be appreciated.

It seems possible that such large supplies of fish could be utilized on a commercial basis. Even if the actual annual productivity of fish is less than the very dense natural populations might suggest, there is so much productive water area, divided among so many small lakes and streams, that a rotation of fishing grounds could easily be arranged, which would keep inroads on the fish population of any one area within safe limits. Obviously certain problems would have to be solved before the establishment of a commercial fishery would be justified. Among these are:

(1) Estimation of the actual annual productivity of waters of representative types. A reliable estimate can be obtained only by means of a fully equipped and intensive limnological survey. Such a survey should investigate not only the actual weight of lake trout, speckled trout, and other fish produced per year, but also the physico-chemical and biotic factors responsible for productivity.

(2) Potential markets. The Knob Lake area is far removed from large centres of population; however distance is becoming a lesser obstacle with modern developments in transportation. The flying time from Knob Lake to Montreal by commercial aircraft is about four hours, and that from areas closer to the St. Lawrence is correspondingly shorter. A charter has in fact been obtained by the mining companies from the Dominion Government for building a railway from Seven Islands to the Knob Lake area. The projected mining developments in the region are certain to provide a local market for at least a moderate weight of fish. Experience at Great Slave Lake[2] suggests that remoteness from centres of population is not in itself an insuperable barrier to the establishment of a fishery.

(3) Conservation and allied problems. Aside from problems of conservation which affect the permanence of the fishery itself, other questions might have to be considered, particularly if the commercialization of speckled trout should seem justified. The laws which now govern the catching and disposal of speckled trout are based principally on the precarious situation of that fish in southern waters, and any recommendation for the modification of these laws to permit the marketing of speckled trout from northern sources would have to include very careful provision, not only for the conservation of the northern populations, but also for the prevention of any adverse reaction on conservation in the south. The possible effect of the depletion of fish populations on the livelihood of Indians in the northern area is another subject which would need careful study.

Commercial fishing in this area should clearly be approached with caution and after due preliminary study. In contrast, the problem of conservation is one which should be faced immediately. The growing population of this area and the development of mining and hydroelectric operations are certain to have an adverse effect upon fish resources over a wide area, unless conservation measures are adequate and prompt. It is to be hoped that these waters will not be ruined, as so many natural resources have been in the past.

[2]Rawson, D. S. "Great Slave Lake", in 'North-west Canadian fisheries surveys in 1944-45'. Fisheries Research Board of Canada. Bulletin No. 72, Ottawa 1947, pp. 45-68.

Photo: U.S. Geol. Surv. by R. R. Coats
Survey geologist taking notes on Kiska volcano, Aleutian Islands.

THE GEOLOGICAL SURVEY IN ALASKA: FIELD SEASON OF 1949*

By John C. Reed†

THE Geological Survey has been making geological, mineral resources and other investigations in Alaska, and has been carrying on topographical mapping there for more than fifty years. Formerly the work was on a very inadequate scale, but the results none the less have been a large factor in the development of Alaska. Shortly before the Second World War, the Alaskan activities of the Survey began to expand, and the expansion has continued until Survey parties are now distributed each field season from Ketchikan to Barrow, from the Canadian boundary at the 141st meridian westward to the islands of the Bering Sea, and southwestward to the end of the Aleutian Chain.

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The Geological Survey is organized into four principal operating divisions, each of which now has Alaska responsibilities:

Geologic Division—Geological mapping, mineral resources investigations, and related activities.

Topographic Division—Topographical and planimetric mapping.

Water Resources Division—Water resources investigations, including surface water, ground water, and quality of water.

Conservation Division—Supervision of development under mineral leases on Federal and Indian lands, and the classification of such lands as to their mineral or non-mineral character and as to their water and power potentialities.

The activities that were carried on by the Survey in Alaska during the season of 1949 are outlined below. The funds for the work are provided largely by direct appropriation to the Geological Survey but substantial amounts are received also by transfers or advances from other federal agencies, including all three armed services, for specific investigations that come within the Survey's fields of special competence.

Many of the Alaskan geologists return to Washington headquarters in the winter to prepare reports and to use the laboratory and library facilities there. However, to facilitate its Alaskan work the Geologic Division has established a sub-office in San Francisco which serves as headquarters for some of the geologists; other Alaskan activities are carried out from Denver, and a few geologists now have their headquarters in Alaska in small, centrally located offices at Juneau, Cordova, Palmer, and Fairbanks.

The Alaskan operations of the Topographic Division are handled from the office of the Rocky Mountain Region of that division in Denver.

The Water Resources Division has assigned a District Engineer and several other engineers to perform surface water investigations, with offices at Juneau and Palmer. Ground water investigations are carried out by a ground water geologist and several assistants. A quality of water office and laboratory has been established at Palmer. The land-classification responsibilities of the Conservation Division relating to water power are undertaken by the Tacoma office of that division, and those relating to minerals are handled in Washington.

Geologic Division

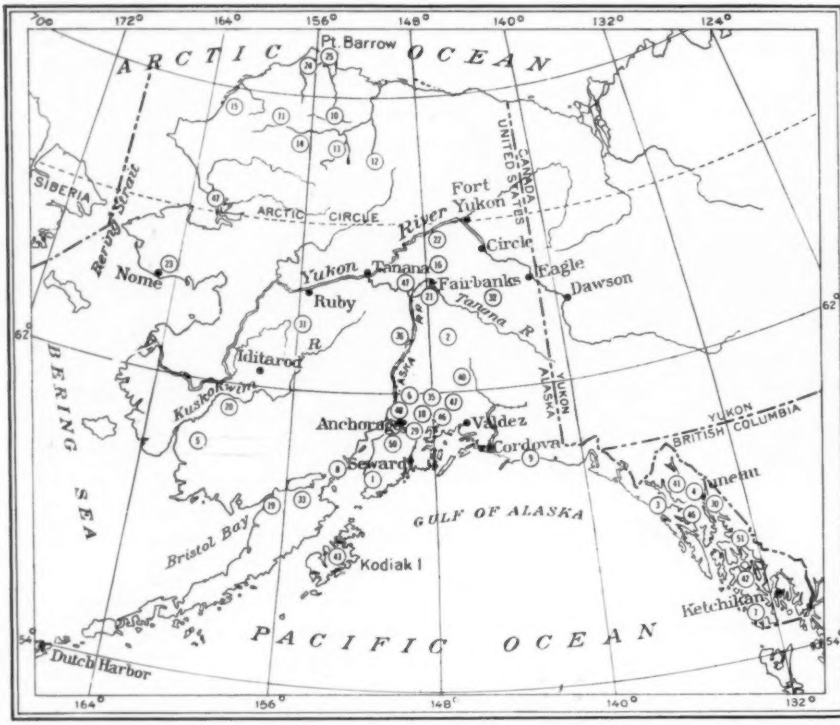
The diverse activities of the Geologic Division in Alaska can be considered conveniently by type of investigation. During the 1949 season the following were underway:

Coal investigations:

(1) Coal investigations were continued for a second full season in the Homer area on the Kenai Peninsula. The Tertiary rocks of the western part of this peninsula contain large coal resources. The collection

of information necessary for coal-land classification, which formed a substantial amount of the work of the party, was carried out for the Conservation Division.

(2) Coal investigations were continued eastward from the Nenana River area, caches being placed by helicopter. This was the sixth consecutive season that this large coal-bearing area had been under investigation. The complete project will cover approximately 1,800 square miles.



Some Geological Survey field projects in 1949. (Numbers correspond to project numbers in the text.)

Gold and associated metals:

(3) Geological mapping and study of the mineral possibilities in the Chichagof Island–Icy Strait–Glacier Bay region were continued, with the aid of a recently purchased 36-foot boat.

(4) The study of the Juneau district and adjacent parts of the Juneau mineralized belt has been underway for three seasons and the field work is now essentially complete. The geologists have their headquarters at Juneau and the project has been conducted on a year-round basis.

(5) The past summer's work completed a long-range geological

mapping project and appraisal of mineral resources in the Lower Kuskokwim region. This includes an area of 6,000 square miles of which about half is covered by alluvium.

(6) A project was continued in the Willow Creek mining district north of the Matanuska Valley. The area contains important resources of lode gold and the systematic and detailed study of the structural geology may yield information on the localization and emplacement of the lodes.

Photo: U.S. Geol. Surv. by F. F. Lawrence

Independence Mine, Willow Creek district, one of the most important producers in the region.

The project was initiated in 1948 and is expected to cover three seasons.

Limestone and other investigations:

(7) The limestone resources on the west coast of Prince of Wales Island in the Tuxekan Island area were studied in the first half of the season. Later the same party investigated magnetite deposits in the Tah and Hunter Bay area of Prince of Wales Island; finally they prepared cross sections of Prince of Wales Island along Klakas Inlet and the South Arm of Cholmondeley Sound. The chartered boat *Oseejo* was used for transporting the party.

Petroleum investigations:

(8) A party continued stratigraphical and paleontological studies on the west side of Cook Inlet northeast from Chinitna Bay to Tuxedni Bay.

(9) A reconnaissance was made of the Mesozoic rocks in the Alaska Peninsula—Cook Inlet—Bristol Bay region, and the same geologist carried out additional stratigraphical studies in the Katalla-Yakataga area on the Gulf of Alaska.

(10) In northern Alaska a party mapped in the area of Maybe Creek,

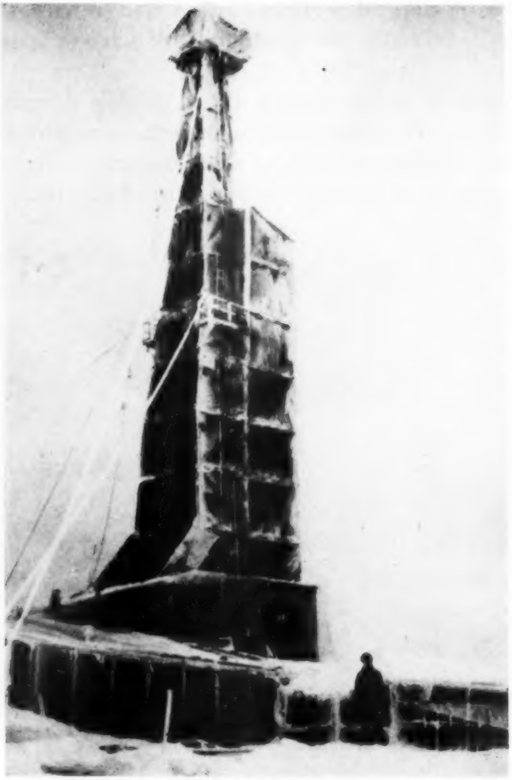


Photo: U.S. Geol. Surv. by J. C. Reed

Partially winterized rig at a test hole site in Naval Petroleum Reserve No. 4.

the upper Ikpikpuk River, and Titaluk River looking for possible "highs" on structures as potential drilling sites for oil.

(11) Another party mapped the geological structure in the area of Carbon Creek and the upper Meade River, and identified possible drilling sites.

(12) Structural studies were made of the Lisburne limestone in selected areas between the Sagavanirktok and Chandler River basins as well as structural and stratigraphical studies of Cretaceous outcrops in the upper Colville River basin.

(13) A party was engaged in the stratigraphical and structural study of Lower Cretaceous and associated rocks in the area of the Kiruktagiak and Killik Rivers. The primary objective was the subdivision of the Lower Cretaceous strata to determine total thickness and contact relationships of the underlying and overlying rocks.

(14) Stratigraphical and structural studies were made of the Etivluk and Kuna River areas and of the Colville River between these rivers.

(15) Another party mapped the geology in the vicinity of the Kukpowruk and Kokolik Rivers with particular attention to the geological structures and possible closures on them.

(16) The Fairbanks office and petroleum geology laboratory, established to carry on certain parts of the Survey's responsibilities in regard to Naval Petroleum Reserve No. 4, continued to operate with a staff of about four geologists with their assistants.

(17) Certain aspects of the work pertaining to Naval Petroleum Reserve No. 4 are performed in Washington. Projects (16) and (17) continue throughout the year.

Photo: U.S. Geol. Surv. by J. C. Reed

Landslide area along the Alaska Railroad between McKinley Park Station and Healy. Track maintenance is difficult in this area underlain by frozen, but otherwise unconsolidated, materials.

Permafrost and terrain investigations:

The permafrost and terrain analysis program of the Geological Survey (Military Geology Branch) is facilitated by a small office in Palmer and includes projects in the following general localities:

(18) In the vicinity of Knik Arm near Anchorage.

(19) In the Bristol Bay area near Naknek.

(20) In the Kuskokwim region, downstream from McGrath.

(21) In the Fairbanks and Dunbar areas.

(22) In the Yukon Flats area between Circle and Fort Yukon and downstream.

(23) Along the southwest and northern margins of the Seward Peninsula. This was a reconnaissance project with the centre of operations at Nome.

(24) A project of permafrost research has been initiated at the Arctic Research Laboratory of the Office of Naval Research at Point Barrow with principal interest in the mineralogy of ice as related to permafrost, including the microscopic study of ground ice.

Geophysics:

(25) A geophysical investigation of permafrost, largely thermal and resistivity studies, has been going on since April as a year-round project at

the Arctic Research Laboratory at Point Barrow. Projects (24) and (25) are closely coordinated.

(26) In connection with the Aleutian investigations outlined below, the Branch of Geophysics has been maintaining a seismic observatory on Adak Island. This observatory is supplemented by another on Great Sitkin Island.

Aleutian investigations:

The program of volcano investigations and related military engineering studies being carried out in the Alaska Peninsula–Aleutian Island region since October 1945 was continued in the 1949 field season. This program is financed jointly by the Geological Survey and the three military services.

(27) A party, using the Survey-owned motor vessel, *Eider*, performed geological mapping and investigations on Attu Island.

(28) Geological mapping and investigations were carried on in the Rat Islands. Transportation was by air and by boat through the cooperation of the U.S. Coast and Geodetic Survey.

Engineering Geology:

(29) General engineering geology studies were conducted in the Anchorage area with particular emphasis on the distribution, availability, and quality of construction materials.

Other investigations:

Additional miscellaneous geological studies were made (30) in southeastern Alaska, (31) in the Ruby–Kuskokwim area, and (32) in the region from Fairbanks east to the border.

(33) Several small mineralized areas were investigated west of Cook Inlet in the general vicinity of Iliamna Lake.

(34) The head of the San Francisco office, and general field supervisor for the Alaskan Section, inspected a number of the projects, planned future activities and personally supervised (35) an investigation of the gypsum deposits at Sheep Mountain.

(36) A party made reconnaissance studies of shales in the vicinity of Mount McKinley National Park in the early part of the season. Subsequently this party initiated a project of investigation of the geology of the park.

(37) In addition to the specific projects listed above, a few more were carried on in Alaska for other federal agencies. Most of these were supported by funds made available by those agencies.

Topographic Division

Alaska Reconnaissance Map Series:

(38) During the past year the Barrow, Nushagak Bay, Fort Randall, False Pass, Pribilof, Ugashik and St. Lawrence 1:250,000 sheets were drafted. Some of these sheets have been published and others will be

available shortly. It is anticipated that about 20 additional maps of this series will be processed during the 1950 fiscal year. These maps eventually will cover all of Alaska and are being prepared in the office of the Topographic Division's Rocky Mountain Region at Denver from all existing source data including ground control, older maps, aerial photographs and navigation charts.

Mile-to-the-inch series of maps:

The small-scale quadrangles of the Reconnaissance Map Series have been further subdivided into smaller quadrangle units on the mile-to-the-inch scale. In a north-south direction four 15′ sheets fall within the 1° 1:250,000 scale sheet. In the east-west direction, the reconnaissance map is subdivided into from five to eight units depending on latitude. During the 1948 season the Navy Department took air photographs of southeastern Alaska and of a small part of the Interior. During the same season field parties established horizontal and vertical control so that more than 30 topographical maps will be published or in reproduction stages by the end of 1950.

(39) Additional aerial photography for mapping was accomplished in the 1949 season by the Navy and by the Air Force. The Topographic Division assigned a field liaison officer between the military photographic units and the Geological Survey.

(40) A party of eight field engineers, with two helicopters, established control and performed operations required for photogrammetric compilation of a substantial number of quadrangles, already covered by vertical photography, in the Glenn and Tok Highway areas from near Sheep Mountain to Tok Junction.

(41) A party of five field engineers, with one helicopter, established control and performed operations similar to (40) above, for quadrangles from Glacier Bay to Juneau and northward to Skagway.

(42) Four field parties performed similar operations for another group of quadrangles in the Craig–Petersburg area.

(43) Field completion and accuracy surveys were conducted for several quadrangles on Kodiak Island. Cartographical operations for these quadrangles will follow late in 1949.

Northern Alaska Planimetric Maps:

(44) The office compilation of maps of northern Alaska on a scale of 1:48,000 was continued. This series of reconnaissance planimetric maps is largely for the use of the Navy Department in exploring the oil possibilities of Naval Petroleum Reserve No. 4.

Aeronautical Chart Service Pilotage Charts:

(45) The Survey is engaged in the revision of pilotage charts of Alaska on a scale of 1:500,000 for the Aeronautical Chart Service of the Department of the Air Force. The work is supported by Aeronautical Chart Service funds. The project is now more than 65% complete.

Water Resources Division

Water resources investigations in Alaska by the Geological Survey, which were renewed in 1946, have developed into a regular and fairly well established program.

Surface water investigations:

(46) A district engineer at Juneau, is responsible for the Survey's surface water investigations throughout the Territory including operation of existing stations, reconnaissance, and establishment of new gauging stations, interpretation of stream flow data, and liaison in connection with the programs and operations of other agencies and units. A hydraulic engineer, at Juneau, is engaged on both field and office phases of the investigations, principally in southeastern Alaska. A hydraulic engineer at Palmer is assigned to the Alaska Railroad Belt and the adjacent coastal and interior regions.

The Water Resources Division has acquired a 76-foot boat for use principally for surface water investigations in southeastern Alaska.

Ground water investigations:

(47) The Survey's ground water program in the Territory includes reconnaissance for municipal water supply investigations throughout the Territory, test well drilling at Fairbanks, Kotzebue, and in the Matanuska Valley, and drilling and establishment of observation wells and related work as the needs of the Survey and other agencies require and as personnel and funds permit.

Quality of water investigations:

(48) A chemist has been detailed to Palmer and has set up a quality of water laboratory. In cooperation with the surface and ground water personnel of the Water Resources Division he has established an orderly program of quality and sediment observations.

Conservation Division

Mineral classification:

(49) Funds for obtaining data for mineral land classification in the field were spent for the purpose by the Geologic Division through inter-division administrative arrangement as indicated under project (1).

Water and power classification:

Water and power classification was carried on by two field parties during the season as follows:

(50) A party completed the survey of Ship Creek near Anchorage and made surveys of two dam sites on Eagle River near Anchorage.

(51) Another party made surveys in the vicinity of Scenery Cove and Ruth Creek at Thomas Bay near Petersburg and dam site surveys on the outlets of Grant and Ptarmigan Lakes near Seward on the Kenai Peninsula.

POLAR NAVIGATION

By Squadron Leader K. C. Maclure, R.C.A.F.

Editorial Note: Aircraft flights to the North Pole, such as the regular U.S.A.F. "Ptarmigan" weather reconnaissance flights from Fairbanks, Alaska, are now routine operations. The navigation of these and other long-range flights of the U.S.A.F., R.C.A.F., and R.A.F. into very high latitudes is based on a special system known as grid navigation, or more accurately, polar grid navigation.

References to this method of navigation have appeared in technical journals, and in the popular accounts of recent polar flights, but the original paper setting forth the ideas on which the present operational techniques are based, has not heretofore been published. Written in October 1941, while the author was on instructional duties at an R.A.F. navigation school in Canada, it remained as a classified document until the end of the war.

In May 1945 the north polar flights of the R.A.F. Lancaster "Aries" (the author being one of the crew) were carried out specifically to test the proposed method. Since then it has come into general use, with minor modifications between the Services.

With the permission of the R.A.F., the major part of the original paper, dealing with the measurement of direction in polar latitudes, is reproduced here. The portions omitted concern the design and use of "astrographs", a type of navigation instrument which saw considerable use during the war, but is now considered obsolete.

I. The Problems Involved in Polar Navigation

While simple methods are now being used for air navigation in normal latitudes, the question of polar navigation has rarely arisen, and at first sight it appears to offer a number of difficulties. It is the purpose of this paper to show that it can be simplified to a large extent.

Before outlining the suggested methods, the various navigational problems which would be met in a trans-polar flight will be enumerated. To understand them clearly consider the case of an aircraft required to fly from A (75°N., 140°W.) to B (80°N., 20°E.). This somewhat exaggerated case will best illustrate the points which will arise in any flight in these high latitudes. Figure 1 is a polar projection of the region, P representing the north pole and A and B the points of departure and destination respectively.

The great circle from A to B, is represented very closely on this projection by the straight line ACB. The distance is approximately 1,480 nautical miles.

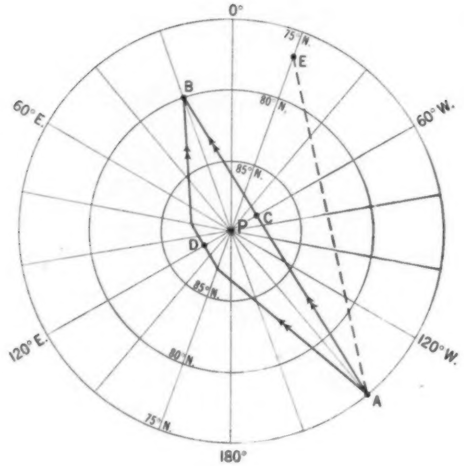


Fig. 1.

On route ACB, in Figure 1:
at A, required track=008°T
at C, required track=090°T
at B, required track=168°T
The rate of change of required track, expressed in degrees True, is most rapid at C, the nearest point to the pole.

Suppose now that the track made good (T.M.G.) was ADB:

at A, T.M.G.=348°T
at D, T.M.G.=270°T
and at B, T.M.G.=197°T

Thus in a flight from A to B, the T.M.G. might have any value from 0–360° at some moment during the trip. Furthermore a normal error in the dead reckoning (D.R.) position, such as would occur during a long flight, might mean that the T.M.G. at the moment, expressed in degrees True, was greatly different from the supposed value.

Notice also, that for any other flight, AE, although the rate of change of Track True may not be as great as at C, it changes continuously and through a large amount from A to E.

To fly the great circle AB, or AE, by a succession of rhumb lines, i.e. by a succession of true courses, would mean a large number of course alterations. These would also be a nuisance to calculate.

The change in magnetic variation is very rapid as the pole is approached (see Fig. 3), it is not very well known, and the horizontal component of the earth's magnetic field is small. Compass courses would be complicated, and might not be very accurate to follow.

Longitude would be changed very rapidly in most cases, and an error of any size in the D.R. position would cause a considerable difference between the actual longitude and the D.R. longitude with consequent confusion when calculating the altitudes and azimuths of heavenly bodies, especially the latter.

When wind-velocities are taken into account, further complications and confusion would probably arise, e.g. referring to Fig. 1, a constant northeast wind over the whole route from A to B, would mean a head-wind to start with, and a tail-wind finally; again, if the wind at C and D

were approximately the same with regard to the aircraft's general track from A to B say from relative bearing of 45°, it would nevertheless be a southeast wind at C, and a northwest wind at D. Or, a constant wind-direction from A to E, with regard to the aircraft's track, would be expressed as a great many different directions in degrees True, as the aircraft progressed.

In order to eliminate these confusing details from the work, and to provide the Navigator with a simple, quick and accurate method of navigating from any point in this region to any other point, irrespective of whether the pole is passed to the right or to the left of the track, or indeed whether the track passes directly over the pole, the following suggestions are put forward. They are divided into three sections: the first on the construction and use of a Polar Astrograph for use during arctic night, the second on the measurement of directions in polar regions, and the third on navigational methods during arctic "Day" and "Twilight."

II. The Polar Astrograph

From approximately October 9 to March 5, the sun will be 6° or more below the horizon of an observer at the North Pole. During this arctic night then, we shall presume that the navigator is able to plan a flight so that the stars will be visible. The question of a trans-polar flight by day, is discussed in a later section.

The simplest method of fixing the position of the aircraft would be by sextant observations of the stars in conjunction with a polar astrograph constructed along the lines of the regular astrograph, but somewhat simpler. This polar astrograph would consist of a projector which would throw the shadow of a set of intersecting star curves on the navigator's chart, similar to the operation of the regular astrograph.

(*Editorial Note:* The description of the proposed instrument is omitted here. Since the date of this paper the astronomical tables used by air navigators for calculating altitudes and azimuths have been extended to the poles, and the astrograph is no longer in general use.)

III. Measurement of Direction in Polar Regions

Referring back to the introduction, it will be noticed that many of the difficulties involved in trans-polar navigation result from the rapid convergence of the meridians. For example, when flying directly over the pole, the course is changed through 180°; and at the pole itself, every direction is south, or 180°T. This is, of course, just because the pole has been chosen as the reference point for directions on the earth. The choice

of another point on the earth's surface far removed from the pole, from which to measure directions while in polar regions, would solve a great many of the difficulties.

Normally, the use of the North Pole, and the system of "True" meridians, is a convenient one, for another reason, viz. that the magnetic needle aligns itself fairly close to the True meridian in most instances. But near the pole itself this is far from the case, as may be seen in Fig. 3, which illustrates approximately the magnetic variation from degrees True. And since the magnetic compass would not be relied upon if celestial observations were possible and would be replaced as a direction-indicator by the directional gyro, continually checked by the astro compass (see below), there seems to be no reason for continuing to use degrees True for expressing directions in these latitudes.

Grid Direction. In fact, as long as one type of conformal map projection were used any system of lines could be drawn on the map from which to measure directions. The present suggestion is that if a projection such as the polar stereographic projection (zenithal orthomorphic) were to be used exclusively for polar navigation charts, polar weather maps, etc., then a system of lines should be drawn, parallel *on the chart* to the meridian of Greenwich. The direction of Greenwich along the true meridian of Greenwich would be expressed as 000° Greenwich or 000° "G", the system of parallel lines on the map being labelled in a similar manner. The opposite direction along each line would be called 180°G, and directions would all be measured in these regions, in a clockwise manner from 0°–360°G, from any one of these parallel lines. A simple formula would connect directions measured on the two systems:—

Direction in °G=direction in °T+180–Long. E. (or+Long. W.)

Thus the difference would be a constant along any true meridian (see grid in Fig. 2). Note that if the opposite direction along the Greenwich meridian were chosen as 000°, then the 180° in the above formula would be omitted.

An alternative system, which might have advantages if several different types of map projection were going to be used, would be to assume a new pole at 00° Long.–00° Lat. and, using great circles through it as a new system of meridians for direction purposes only, express directions relative to that point. This would mean that the reference lines would be true great circles, while on the scheme outlined above they would not be. On the other hand, there would be no simple formula such as that given above to transform directions from one system to the other. Again, since outside of Lat. 75°N.–90°N., normal methods of navigation would be used, the artificiality of the reference lines suggested (for polar regions only) should cause no trouble.

Any other direction besides the direction of the meridian through Greenwich might be used, such as a meridian passing close to the north magnetic pole. This latter method would mean that the variation of the magnetic needle from this direction would not be as large *numerically* as on the other system, but the advantage would be too slight to outweigh

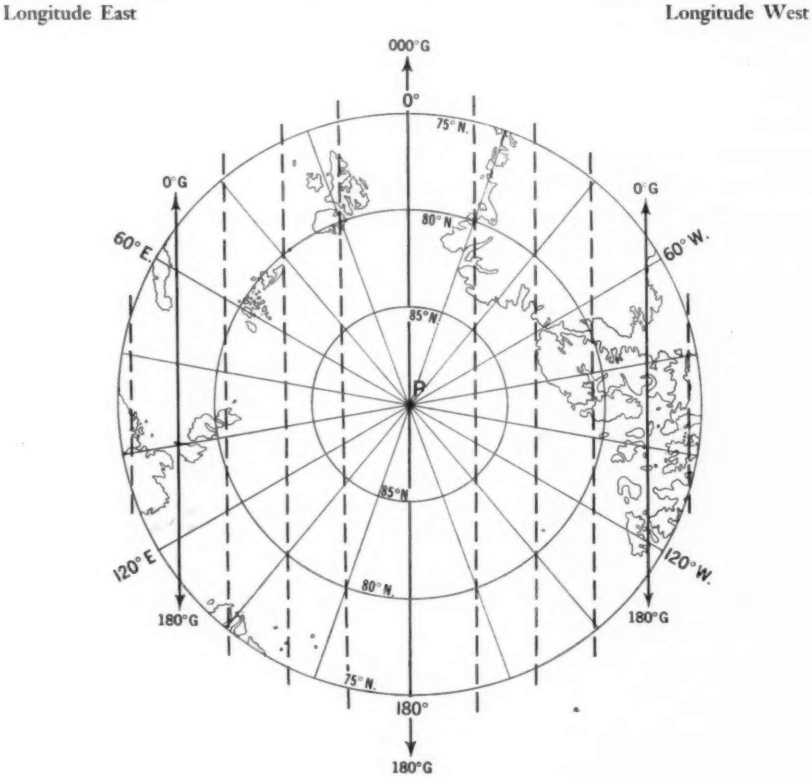


Fig. 2. The Greenwich Grid.

its disadvantages (see below). The same applies to the use of other meridians. For a particular flight, the required track from A to B could be used as a reference line, and all courses and wind-directions measured relative to it. But in case the route was changed, and for the use of weather maps, etc., a simple unchanging standard such as degrees "G",' is considered better.

Great Circle Routes. Since on the stereographic projection, a straight line represents very closely a great circle, the great circle track from A

to B would be represented as a single direction in degrees "G". No alteration of course for convergency would be necessary.

Use of Astro Compass. As the magnetic compass is not likely to be very reliable in polar regions, steering courses by directional gyro (D.G.), with frequent checks by the astro compass, appears to be the best method. Referring back to Fig. 1, if it were required to fly from A to B, and if we assume for the moment that there were no wind, then a perfectly frictionless D.G. would enable the pilot to keep the aircraft on the great circle route from A to B (also ignoring the earth's rotation). Since the D.G. is not frictionless it would have to be checked at regular intervals from bearings of the stars, taken with the astro compass.

It is considered that owing to the rapid change of longitude, and therefore rapid change of hour angle, that the most accurate method of using the astro compass, and the simplest, would be to use it in conjunction with the polar astrograph. The direction of the stars is, of course, at right-angles to the equal altitude circles, in the direction of increasing altitude, so that using the astro compass as a bearing plate, and taking azimuth and altitude from the astrograph, rather than latitude, local hour angle, and declination from the almanac, would be the best and easiest method.

Thus if the directional gyro did not precess, the grid course (Co. "G") could be set on the D.G. at the outset, and would remain the same from A to B, except for changes in the wind-velocity, and the earth's rotation. But owing to friction, the D.G. has to be checked continually and, as explained above, this could be done most easily with the astro compass, using it as a bearing plate, and taking the azimuth and altitude from the polar astrograph. The procedure followed would be to set the polar astrograph properly for time; then at the D.R. position on the chart, read the approximate altitude of one of the stars, ánd measure its direction or azimuth in degrees "G". Setting this latter reading on the astro compass at the arrow labelled "True Bearing," and setting the altitude on the declination scale, the astro compass would then be swung around until the star was sighted. The course in degrees "G" would then be read off the azimuth scale at the lubber line. (*Editorial Note:* The astrograph is no longer in general use, tabular methods of calculating altitude being adopted for all latitudes. Similarly current practice on polar flights is to set Lat., L.H.A., and dec. on the astro compass as in normal latitudes, thus obtaining Co.T., *but then converting to Co."G"*, by simple formula as explained earlier in the paper, using *exactly the same figure* for longitude as used in calculation of local hour angle from Greenwich hour angle. "Assumed longitude" can be several degrees in error without affecting

accuracy of resulting Co."G".) Since the gyro precession owing to friction is much greater than that owing to the earth's rotation, the latter can be ignored.

Referring to Fig. 2, it will be seen that an error of 100 miles or so, in the D.R. position would mean but a small error in the calculated (or measured) bearing of the star in degrees "G". Consequently, when this bearing is set on the astro compass, as explained above, the resulting measurement of the course in degrees "G" is only slightly in error, the error being of about the same magnitude as would exist if the procedure were followed in normal latitudes. But it will also be observed that in high latitudes, if the bearing were measured in degrees True, an error in D.R. position of 100 miles might mean a considerable error in longitude, which would mean a considerable error in the calculated bearing of a star in degrees True, with the same error resulting in the measurement of the course in degrees True. Since the error, and the confusion which it would cause, results solely from the use of true north as a reference point for direction, it provides a strong argument for using degrees "G" rather than degrees True in these latitudes.

Measurement of Wind Directions. In the first paragraphs of this paper, describing the problems of trans-polar navigation, it was pointed out that a constant wind speed from a constant direction in degrees True, means a continuously changing wind-velocity, relative to the required track. Conversely, a constant wind, relative to the desired track, is expressed as a wind blowing from a continuously changing direction in degrees True. Since the aircraft will only have to alter course due to change in wind when either the speed of the wind or its *direction relative to required track changes*, measurement of wind direction in degrees "G", will overcome this problem also. Actually, the wind direction could be expressed relative to the required track AB, but this would not have the same advantages as always expressing it relative to the same direction, the meridian of Greenwich, i.e. in degrees "G".

It is suggested then that the weather map for the region should have the "G" lines marked thereon, and the weather forecast for the route express wind directions in degrees "G". By using the simple formula for changing True to Grid these directions could always be changed to degrees True when required, such as near the 75th parallel, where the polar chart would join the chart for lower latitudes.

Navigating from Lower Latitudes into Polar Regions. If an aircraft were flying from lower latitudes into polar regions it is suggested that the navigation be carried on in the usual manner, expressing directions in degrees True, until 75°N. is reached. Then, if the position of the aircraft

were marked on the polar chart, and the required track laid down, navigation from there on should be carried out by the scheme outlined above.

Measurement of Position. A rectangular system of expressing position could be superimposed on the chart, but this is not considered advisable. Since tracks, distances, positions, etc., in air navigation, are mea-

Longitude East Longitude West

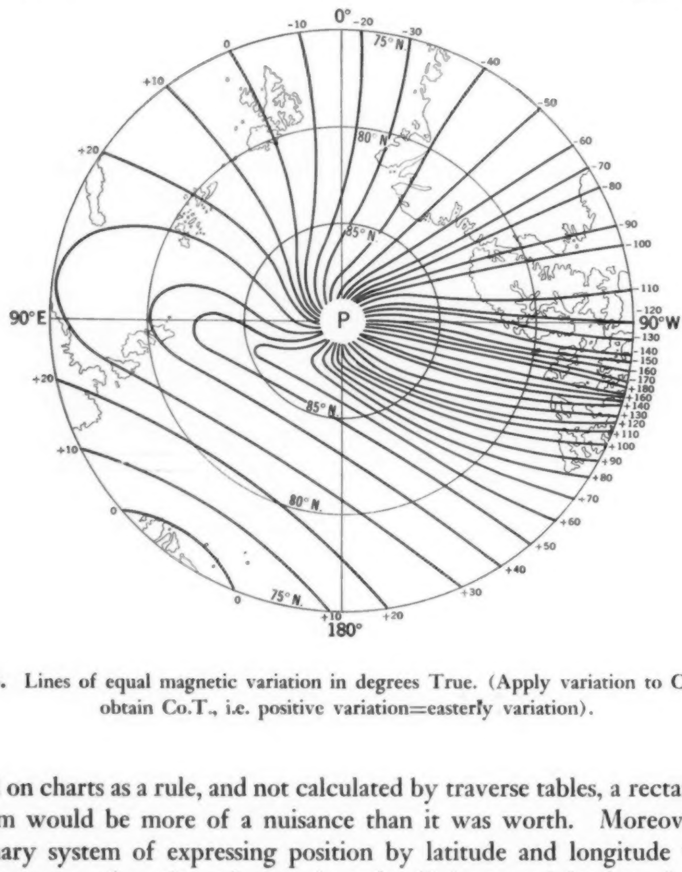


Fig. 3. Lines of equal magnetic variation in degrees True. (Apply variation to Co.M. to obtain Co.T., i.e. positive variation=easterly variation).

sured on charts as a rule, and not calculated by traverse tables, a rectangular system would be more of a nuisance than it was worth. Moreover the ordinary system of expressing position by latitude and longitude would be necessary when the polar portion of a flight were joined to the non-polar portion. It is considered that the ordinary system of expressing positions by latitude and longitude should be retained for polar navigation.

Variation. Referring to Fig. 3 it will be noticed that the magnetic variation changes very rapidly near the pole, partly owing to the proximity of the magnetic pole, but also owing to the use of the north pole as the point from which directions are measured. It will be noticed that by

flying a small circle around the pole, 360 degrees of "True" variation is passed through.

Fig. 5 shows approximately what the horizontal force of the earth's magnetic field is likely to be. This map, like the specimen variation chart, Fig. 3, has been produced by extrapolating the curves for lower latitudes, taking into account the location of the north magnetic pole, and the

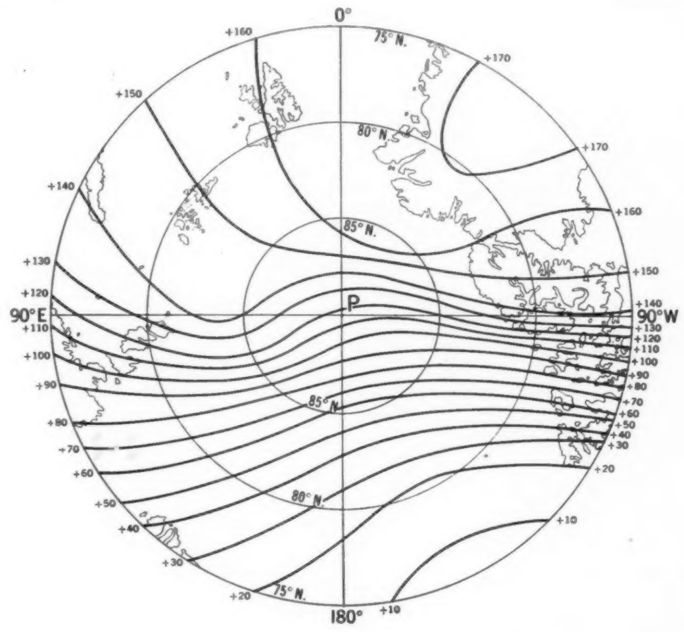


Fig. 4. Lines of equal magnetic variation in degrees "G". (Apply variation to Co.M. to obtain Co.G.)

probable direction of the magnetic lines of force in this region[1]. It is suggested that in certain parts of the polar region, the horizontal force will be sufficient to allow a magnetic compass to give an approximate indication of direction, provided that it is not corrected too much for deviation,[2] or shielded too greatly. If this is the case, then during bad weather or when the stars are obscured for a time, the magnetic compass

[1]Based on information available to the author in 1941. Some differences from recent charts may be seen as a result of the change in the position of the north magnetic pole. *Ed.*

[2]This opinion is partially in error; experience has shown that if a deviation-free position for the compass cannot be found, the effect of the aircraft's magnetism must be very carefully nullified by magnetic correctors.

might be relied upon to some extent. An earth inductor compass or "double pivoted" magnetic needle might give better results as changes in magnetic dip do not affect them like "single pivoted" magnetic needles.

To make the use of the compass much easier, the numerical values of the variation should be expressed relative to the direction of the Greenwich meridian, i.e. the variation from 000°"G", and isogonals drawn for

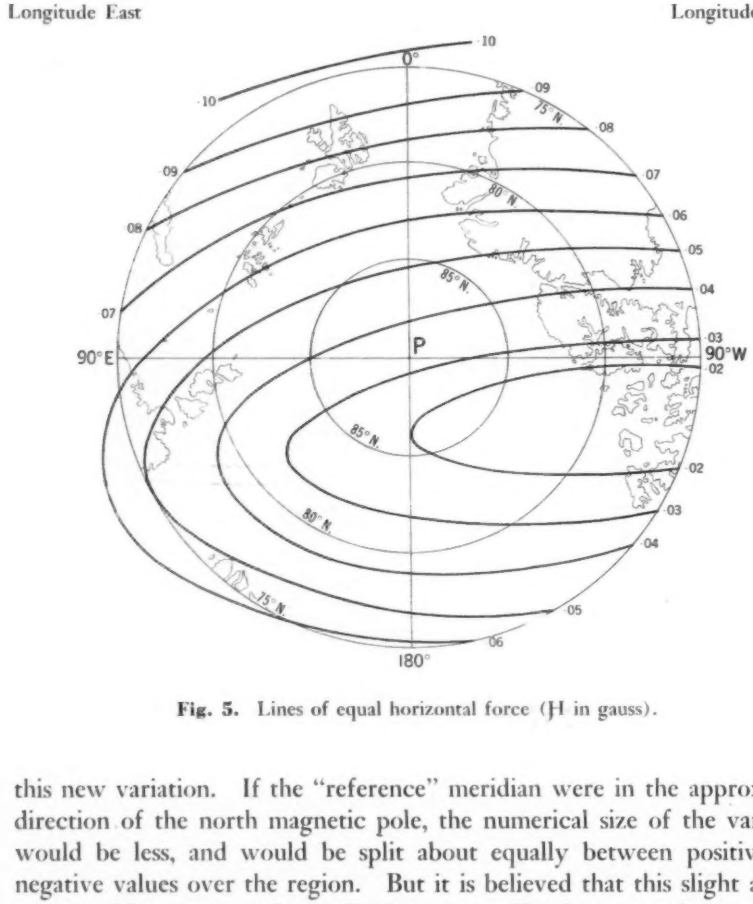


Fig. 5. Lines of equal horizontal force (H in gauss).

this new variation. If the "reference" meridian were in the approximate direction of the north magnetic pole, the numerical size of the variation would be less, and would be split about equally between positive and negative values over the region. But it is believed that this slight advantage would not outweigh the disadvantages. Furthermore, the expression of the variation from 000°"G" as a number, positive always, from 0–360°, which when applied to the course Magnetic results in the course "G", would be the simplest method, and the one least likely to produce errors.

As with the expression of wind directions in degrees "G", the expression of the magnetic variation in the same system, would enable the navigator to tell at a glance how many times he should alter his *course*

Magnetic in order to fly from A to B (presuming he was using his magnetic compass).

Figure 4 shows approximately what the isogonals on the new system would look like. It will be noticed that the range of variation is not as great as on the old system (Fig. 3), and that the isogonals are more nearly parallel, making the use of them considerably simpler.

IV. Arctic Day and Twilight Navigation

For miscellaneous sights, which would include the sun, planets, moon, and odd stars with declinations between 10°S. and 30°N., the scheme proposed is to use a "Baker Machine" type of Astrograph, using 4 sets of curves for declinations 5°S., 5°N., 15°N. and 25°N., respectively. (*Editorial Note*: Remainder of description of this instrument omitted here).

Watch Errors. (This applies to stars as well as sun). Since fixes from a correct sextant (no accel. error), but an incorrect watch, are correct as to latitude, but incorrect as to longitude being displaced east or west 15′ of longitude for every minute of watch error, an error of 4 min. of watch time will cause a 1° error in the longitude of the fix, which is only 15 n.m. at Lat. 75°; 10 n.m. at Lat. 80°, etc. Watch time could be recorded then to the nearest ½ minute, since errors of ½ minute of time would cause errors of less than 2 miles.

Rate of Change of Azimuth. It may be thought that near the pole the azimuth changes rapidly. If an aircraft is flying near the pole, the *true azimuth* would change rapidly, but on reference to Fig. 2 it will be seen that the *azimuth in degrees* "*G*" will change slowly. It is therefore out of the question to hope to obtain a running fix from successive sun observations.

Navigation during Arctic Twilight. At the North Pole, the sun is above the horizon for 6 months of the year, and below it for the remaining time. When it is 6° or more below the horizon, it is presumed that the stars would be used for navigation. During the "Day", single position lines would be obtained from the sun, and if the flights were planned so that the position lines from the sun were parallel to the track when nearing the destination, navigation using the sun alone would be quite satisfactory.

But during twilight, the planets or moon would probably be used as much as possible. The moon would be useful for varying periods of time each year, and Venus and Mars could be used at times, depending on their declination. Saturn and Jupiter would be very useful, since they both have northerly declination at the present time (October 1941) and will

have for some years to come. Polaroid filters, and telescopic attachments for the bubble sextant would increase the usefulness of the stars.

Refraction. For the stars chosen for the polar astrograph, the astronomical refraction is not great, and has been allowed for in constructing the star curves. But while taking observations of the sun when it is very low, the correct amount of refraction is of considerable importance. Owing to the very dense atmosphere over the pole, special tables might have to be made for low altitude sights.

Summary

It is believed that the problem of navigation in polar regions would be greatly simplified by the following suggestions:

(a) That during the arctic night, courses be flown by directional gyro, checking continually by observations with the astro compass of the stars selected for the astrograph, using the astro compass as a bearing plate, and obtaining the altitude and azimuth of the stars from the astrograph.

(b) That all directions in polar regions (Lat. 75° to 90°) be measured relative to a system of parallel lines drawn on a conformal polar projection (such as the stereographic), parallel to the meridian of Greenwich; that the direction towards Greenwich on its meridian be called 000°"G", and similarly on the system of parallels; that any other direction be measured from this direction, in a clockwise manner from 0°–360°"G".

(c) That weather maps, forecasts etc. use degrees "G" for the expression of direction in polar regions.

(d) That isogonals be drawn on the charts, giving the magnetic variation as a positive number, from 0° to 360°, which, by applying to the course Magnetic, will produce the course "G".

(e) That positions continue to be measured in latitude and longitude in the normal manner.

No. 31 Air Navigation School,
Royal Air Force,
Port Albert, Ont.,
Canada, October 1941.

REVIEW ARTICLE

TWO SUMMER EXPEDITIONS TO NORTHEAST GREENLAND

THE COAST OF NORTHEAST GREENLAND, with hydrographic studies in the Greenland Sea. *By* LOUISE A. BOYD. *New York: American Geographical Society (Special Publication No. 30), 1948. 10 x 6½ inches; xl + 340 pages; illustrations and maps. $6.00.*

Another important volume on the East Greenland expeditions carried out by Louise A. Boyd has recently been issued by the American Geographical Society. At government request publication was withheld during the war. It now appears as Special Publication No. 30 and, in keeping with the other volumes in the series, is beautifully produced.

Miss Boyd, who visited the Arctic for the first time in 1924, has now taken seven summer expeditions to northern regions. Ladies are not generally represented in the exploration of polar countries, but Louise Boyd has proved herself to be a most capable leader. She has throughout shown a very real respect for Danish authority and has always offered assistance to other expeditions if required. Her personal contribution to northern work lies in the thousands of fine photographs she has taken from Zemlya Frantsa-Iosifa (Franz Josef Land), Spitsbergen, Jan Mayen, and East Greenland.

It is, no doubt, not just a matter of chance that Miss Boyd has been specially attracted by the East Greenland coast, for in no other place in the Arctic are there such long fjords and such high mountain walls, which provide particularly beautiful subjects for a photographer. She mentions in her book that she would like to take some colour photographs in East Greenland. It is questionable however, whether colour photographs in these regions should not be taken either in the fall, when the brilliant sunsets, especially before and after a gale, are of unique beauty; or perhaps in the month of May, shortly after the first appearance of the mid-night sun, when unusual colour effects may be observed. The writer, who has visited these regions both in the spring and in the fall, has a clear remembrance of unforgettable colour effects in the fjords at these seasons.

Although Louise A. Boyd has worked out the scientific programs for her summer expeditions with great forethought, on reading the various chapters of the book one deplores that the scientists had not more time at their disposal. It may be asked whether summer expeditions to the fjords of central East Greenland are not now out of date. The working time of such expeditions is too short and too much depends on the ice conditions, which may interfere considerably with the planned scientific work. A number of Danish expeditions have already wintered in East Greenland, and since 1931 Danish expeditions have established winter stations for scientists, who thus obtained a much longer working period.

The book under review deals especially with the 1937 and 1938 expeditions. Neither of these was a favourable ice year, but in spite of this Miss Boyd and the members of her expeditions obtained good results. In 1938 the expedition pushed as far north as Ile de France, which is very difficult to reach by ship. On p. 63 Miss Boyd puts forward the conjecture that their landing there at 77°48N. "was at that time the farthest north landing ever made from a ship on the east coast of Greenland". In fact in August 1933 the Danish ship *Gustav Holm* pushed as far north as Norske Øer (Norske Islands), a little north of 79°N., where a landing was made; if time had permitted, she might even have proceeded in ice-free water to some distance north of Nordostrundingen in lat. 81°30N. (For the ice conditions along the coast of Northeast Greenland in August 1933, see *Medd. om Grønland* Vol. 130, No. 3 (1945) fig. 138).

The chapter on "Glacial geology and geomorphology" by Dr. R. F. Flint, who was assisted by Dr. A. L. Washburn, is outstanding. So far there has been very little research on glacial geology in these parts of the Arctic, and although the two scientists had only a short time for their work in 1937, they secured much information on the glaciers of East Greenland. We know now that during the last two centuries the Icelandic glaciers have advanced, and that for some of the glaciers it may be the greatest advance in post-glacial time. From observations made in Iceland, we further learn that nothing similar to the vast extension and frequent blockings of the coast of Iceland by the East Greenland ice during the three centuries from c. 1600 to c. 1900 is known to have occurred in the period from c. 800 to c. 1600. During this period, with the possible exception of the 13th century, Iceland was practically untouched by the East Greenland ice, as is the case today. It would seem from this evidence that both Iceland and East Greenland have experienced a small "ice-age". Probably this recent glacier advance can be mapped in East Greenland. At present, however, the glaciers of East Greenland are retreating. Dr. Flint's account of the East Greenland glaciers is an excellent introduction to continued investigations in this field.

The 1938 expedition was joined by Mr. F. Eyolf Bronner as geologist. After a few hours on Ile de France, Mr. Bronner visited the Orienteringsøer (Orientering Islands) and Store Koldewey (Great Koldewey Island). On p. 217 he gives an excellent table of the probable geological history in the region visited. It is to be regretted that he was not able to make more comprehensive observations in these geologically little-known regions, but he has given us many interesting details.

Dr. Henry J. Oosting, Miss Alice Eastwood, and Miss Boyd all write on botanical subjects. It is, of course, always valuable to have a large Arctic herbarium secured during a number of years. Their observations on ecology, I have been told by a Danish botanist who has been at work in East Greenland for several years, are somewhat one-sided, as they were chiefly made in the interior of the fjords. These chapters therefore do not contain much new information, particularly since in recent years the central part of East Greenland has been thoroughly investigated by both Danish and Norwegian botanists.

The most valuable results of Miss Boyd's 1937 and 1938 expeditions, in the writer's opinion, are hydrographical. This work is described by Mr. James M. LeRoy. At a fairly early date the Boyd expeditions began taking echo soundings in the East Greenland fjords, and this work was subsequently extended to the whole sea area between East Greenland, Jan Mayen, Spitsbergen, and Norway. Here the so-called Louise A. Boyd Bank was discovered between Jan Mayen and Bjørnøya (Bear Island), which caused an alteration of the existing bathymetrical charts on essential points. On p. 297 some details in the Danish bathymetrical chart of 1932 by R. Spärck (*Medd. om Grønland* Vol. 100, No. 1 (1933)) are criticised. LeRoy is probably correct in his criticism, for the echo sounder at the disposal of Professor Spärck in 1932 was very primitive.

Finally the book contains chapters on Topographical Surveys, Current Observations, Tide Observations, and Magnetic Observations. The topographical surveys, in particular, have provided the basis of a number of good detail maps, which will be of importance for future research work, especially in the measurement of glacier oscillations. The chapters by Flint and LeRoy on their glacial and hydrographical observations are those parts of the book which carry the greatest weight.

LAUGE KOCH

REVIEWS

NEW WORLDS EMERGING.

By Earl Parker Hanson. *New York: Duell, Sloan and Pearce, 1949. 8½ x 5½ inches; xix + 386 pages; end-paper map. $3.50.*

For a quarter of a century the author lived and worked in Chile, Iceland, Canada, the Amazon Basin, the Northern Andes, Puerto Rico and Liberia. As an engineer and planner he learned his geography in the field and now as Chairman of the Department of Geography at the University of Delaware he finds much to disagree with in the work of academic geographers. There is much a specialist can find to disagree with in his interpretations and opinions, and his excursions into the fields of political economy and economics, population problems, and the management of resources both material and human.

The strength of the book lies in the fact that he has written about areas which he knows at first hand. The treatment is not claimed to be comprehensive, but he has singled out some of the most significant problems and developments in these areas, as well as using them as illustrations and examples of the central theme of the book. This theme is that the energies of the men, capital and technology of North America are not now being directed into the temperate areas of the world but into the Arctic and tropics where new worlds are emerging. Great emphasis is placed on the need for changes in racial concepts and in the attitude to undeveloped peoples, whom he considers to be as important an economic frontier as undeveloped land and material resources.

He traces through history the widespread misconception that the tropics and the Arctic are both impossible as permanent homes for white men, and that no real civilization can arise or thrive there. In his discussion of the Arctic in this respect, he has been influenced by the work of Stefansson.

The author has done most of his work in the deserts and tropics and the Arctic section of the book will be disappointing to the Arctic specialist in that it contributes little that is new in substance or in point of view. It is confined to four areas, namely Iceland, the Polar Sea, the Soviet Arctic and Alaska.

The historical development of Iceland is traced in outline, through the colonial phase of economic and social poverty, which was interpreted by many to show that they were unfit for self-rule, lacking in moral fibre and a sense of responsibility, and the gradual political and economic emancipation leading to the present state, which, "functions so well that their nationals cannot be persuaded to emigrate."

The history of the exploration of the Polar Sea is described briefly, with particular attention to the work of Stefansson and Wilkins who have done so much to shatter the old illusion of the desolate and lifeless Arctic. This illusion persisted in spite of the fact that the necessary data had been observed and recorded for half a century, but had been ignored because it did not fit the pattern of established thought.

The Soviet Arctic and Alaska are briefly reviewed. The emphasis in the former case is on the variety of fields in which progress has been made to establish permanent populations in areas which would earlier have been dismissed as impossible for civilian communities. In the latter case the author confines himself mainly to the varying schemes and plans for the development of Alaska by the United States government.

I.B.

GRØNLAND (Greenland).

By Jette Bang. *Copenhagen: Det Grønlandske Selskab (The Greenland Society), 1941. 10¼ x 9 inches; 187 pages.*

GRØNLAND. *Copenhagen: The Greenland Administration, 1947. 13 x 10½ inches; 96 pages.*

These two books of Greenland photographs are remarkably good and yet so very different.

Jette Bang's professional photographs are probably the best that have ever been made in Greenland and show the result of a rare combination of high skill in handling camera and subject, combined with intimate knowledge of Greenland and a deep understanding and sympathy for its people. The photographs were made in the course of Miss Bang's several visits to Greenland before the last war. Many of the portraits are masterpieces —to be classed with the best of Yousuf Karsh's portrait studies. The reproduction, likewise, is exceptional; the text is in Danish but most of the photographs tell their own story.

The second book may be described as documentary rather than pictorial art and was produced for the Greenland Administration by Berlingske Tidende—one of Denmark's leading newspapers. The excellent selection, from newspaper files and from the photo-archives of the Greenland Administration, was made by Mr. V. Borum, who is in charge of the Cultural Division of the Administration's Copenhagen office and was for many years a schoolteacher in Greenland. The text, in both Danish and English, is instructive and authoritative.

A. E. PORSILD

INSTITUTE NEWS

The Baltimore-Washington office of the Institute

Since 1946, there has been a steady increase in the number of field projects supported by the Arctic Institute of North America. In the first season, three teams of investigators went into the north with the support of the Institute. Last summer, more than twenty-five parties were in the field ranging from the western tip of the Aleutian Islands to the coast of Labrador, and from Point Barrow, Alaska, to Devon Island in the Canadian Arctic Archipelago. An Institute aircraft and the loan of the schooner *Blue Dolphin* for research in Arctic waters have contributed materially to the Institute's research program. Interest in the Arctic and desire by scientists to do work in the north seem fortunately to be increasing.

The Institute therefore decided that an office was required to deal with its research projects. In October, 1949, the Baltimore-Washington Office was established in quarters provided through the courtesy of the Johns Hopkins University. In addition to dealing with grants-in-aid for arctic work, field reports, progress reports and technical reports of the Arctic Institute the Baltimore-Washington Office will keep in touch with arctic research in general.

The Director of the new office in Baltimore is Dr. M. C. Shelesnyak, who was formerly Head of the Ecology Branch of the Office of Naval Research in Washington. Dr. Shelesnyak is a physiologist by training and has made a special study of the relationship of man and animal to their environment. During the war as an officer in the U.S.N.R., he served as an Aviation Physiologist in various posts. While serving with the Deputy Chief of Naval Operations (Air) he was U.S. Naval Observer on Exercise Muskox (Moving Force). Following his return to civilian life, he joined the ONR staff and was largely concerned with arctic research. In his official capacity he was responsible for the development of the U.S. Naval Research Laboratory at Point Barrow, Alaska.

The address of the Baltimore-Washington Office is Rogers House, The Johns Hopkins University, 3506 Greenway, Baltimore 18, Maryland.

Expedition to Baffin Island in 1950

Plans are being made at the Montreal Office of the Institute for a scientific expedition to Baffin Island in the summer of 1950. The expedition, which will be led by P. D. Baird, Director of the Montreal Office, plans to study the residual ice cap inland from the post at

River Clyde, and the surrounding country on the east coast of Baffin Island, in approximately latitude 70°N.

The party will number about twenty scientists and student assistants, and will include Dr. E. H. Kranck as geologist and Dr. Pierre Dansereau as botanist. The other main fields of investigation will be glaciology, zoology, and permafrost.

The main glaciological work will be the study of the ice cap, which lies on rolling tundra and is separated from the coastal mountain belt. Apart from the interest of studies on a probably shrinking ice cap, this work will help to fill the gap between the nearest other detailed glaciological investigations in Greenland and in the St. Elias Range of Western Canada. Accumulation and ablation will be measured and attempts will be made to sound the depth of the ice, to determine temperatures both within and immediately above its surface, and to study any flow and the growth of ice crystals.

Geological reconnaissance of the area which is mainly Precambrian, will be carried out as widely as time permits. Particular studies will be made of the petrology, including granitization, and of possible comparisons with similar rocks in Greenland and Labrador. The uplift of the coastal region, where glacier and moraine covered peaks rise to over 5500 feet, will also be examined.

These peaks are attractive to mountaineers and a group from the Swiss Foundation for Alpine Research will be joining the expedition to spend the summer climbing and making scientific observations among the scenically magnificent fjords and mountains.

An important part of the expedition's work will be the examination of plant colonisation sequences on the margins of the ice cap and other areas of permanent snow. Zoological collections will also be made and the caribou distribution studied.

By drilling into the permanently frozen ground it is hoped to discover more data about this phenomenon of the north, particularly in the immediate vicinity of the ice cap in ground which has probably become recently uncovered as the ice cap shrinks in area.

The party will be flown to the River Clyde post by the Royal Canadian Air Force in May and most of the members expect to leave in early September by the new Canadian Government patrol vessel, *C. D. Howe*. In the field transport will depend on the Institute's Norseman aircraft, which has proved its worth in the Yukon, and on canoes. The greater part of the heavy stores has been taken to River Clyde by sea this summer.

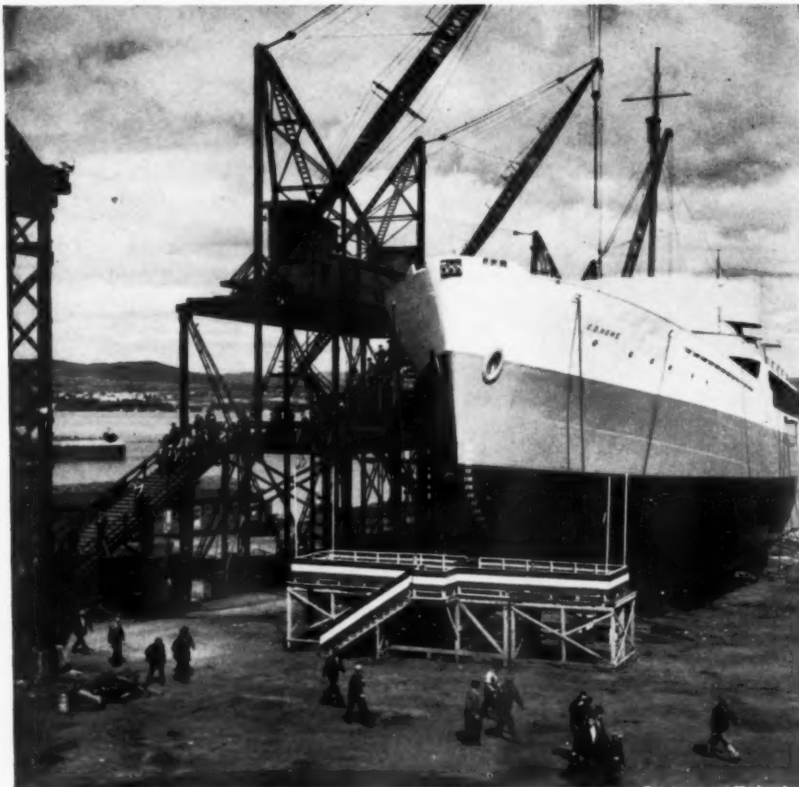


Photo: Dept. of Transport

The new Eastern Arctic Patrol Ship, *C. D. Howe*, at Levis, P.Q.

NORTHERN NEWS

Vessels for the Canadian Arctic

Recently there have been important developments in the two major vessels under construction for use in the Canadian Arctic, and the Department of Transport has announced that a new twin-screw icebreaker will be built for its Service.

New icebreaker for the Department of Transport

The main task of the new icebreaker will be the supplying of far northern stations during the summer; the rest of the year she will be employed icebreaking in the Gulf of St. Lawrence and in the St. Lawrence River.

Details of the plans for the ship have not been announced, but it is reported that the icebreaker will be the largest in North America. She will be specially equipped for carrying and landing supplies and will have a large refrigerated storage capacity. In addition to all the most recent navigation aids it is anticipated that she will normally carry two helicopters for reconnaissance work.

Launching of the Eastern Arctic Patrol Ship

The new Eastern Arctic Patrol Ship, the *C. D. Howe*, was launched from the Davie Shipbuilding and Repairing Company's yards at Levis, Quebec, on September 7. Owing to delays in construction she was not ready for the 1949 northern patrol as originally intended. An account of this ship, which will be

operated by the Department of Transport, was given in *Arctic* Vol. I, No. 2, (1948) p. 121.

During the summer months the *C. D. Howe* will carry the Government freight and personnel for the Eastern Arctic, formerly carried by the Hudson's Bay Company's R.M.S. *Nascopie*; the rest of the year she will be assigned to Department of Transport duties on the East Coast and the Gulf of St. Lawrence. Her appearance is workmanlike, but modern, with a raked stem and a cruiser stern, two continuous decks and three cargo holds which have steel covers on their weather deck hatches. Her overall length is 294 ft. 6 ins. and her draft fully loaded 18 ft. 6 ins., not 18 ft. as previously announced. The *C. D. Howe* will be registered in Ottawa.

Laying of the keel of the new Royal Canadian Navy icebreaker

The keel of the new R.C.N. icebreaker was laid at a ceremony on November 18. This vessel, which is under construction at the Marine Industries Yards at Sorel, Quebec, was described in *Arctic*, Vol. 2, No. 2 (1949) p. 75. It is expected that the icebreaker, which is similar in some respects to the U.S. Wind Class, will be completed in the summer of 1952.

In Canada there are at present only four ships operating which were built as icebreakers: the *N. B. McLean*, *Ernest Lapointe*, *Lady Grey*, and *Saurel*.

Archaeological work on Cornwallis Island

Last summer, Dr. H. B. Collins, of the Smithsonian Institution, and his assistant, Mr. J. P. Michea, of the National Museum of Canada, excavated old Eskimo sites in the region of Resolute Bay, Cornwallis Island, in the Canadian Arctic Archipelago. The project was a joint one between the National Museum of Canada and the Smithsonian Institution. These excavations are of particular interest as the first to be made in the northern part of the Canadian Archipelago. All the sites excavated appeared to be pure Thule culture with no signs of Dorset influence.

Ruins of four villages, of from 6 to 14 houses, were found. The houses were of the usual Thule type, being made of stones, whale bones, and turf. Excavations in the houses and adjacent middens yielded a considerable quantity of cultural material, all of it representative of the Thule culture. Several examples of pictographic art were found, including one showing a whale being harpooned from a umiak.

Very few examples of pictographic art have been found at Thule sites in Canada or Greenland, and this one showing a typical Eskimo umiak, with the steersman in the stern, three paddlers and the harpooner in the act of hurling a harpoon at a whale is a fine example. The Thule people were primarily whale hunters, and from skulls and other evidence the Bow Head whale appeared to be abundant in their time. Today there are none in the region.

A composite stone and pottery lamp found is unique in arctic excavation. It has a flat limestone slab for a base and a built-up side of pottery.

The death of Nukashook[1]

At Cambridge Bay on September 2 and 3, two 21-year old Netsilik Eskimo from Boothia Peninsula, Eeriykoot and Ishakak, were tried before Stipendiary Magistrate A. H. Gibson with a six-man jury on charges of assisting the suicide of a 45-year old Eskimo woman, Nukashook, the mother of Eeriykoot.

The evidence showed that Nukashook, who was in an advanced state of tuberculosis and in pain, had repeatedly requested her son to help her to die, in accordance with an old Eskimo custom whereby it is the duty of the children to assist old or sick Eskimo who desire to kill themselves. Last summer Eeriykoot asked his friend Ishakak to help him in this task. They went to Nukashook's tent and arranged a loop of sealskin line from the ridge-pole. Nukashook placed her head through the loop, requesting her son to hurry the procedure. Eeriykoot then pressed down on the back of her head until she was dead. No attempt was made to conceal the act and the neighbours were informed and assisted with the burial.

Both Eeriykoot and Ishakak are intelligent men, able to read and write in

[1]Reprinted from the *Arctic Circular*, Vol. II, No. 6 (1949) pp. 71-2.

syllabics. At the trial Eeriykoot said that he would have considered it wrong not to help his mother when she asked him. Apparently realizing that the white man might object to their action, both men were reluctant to take part and only agreed on the insistence of Nukashook.

Eeriykoot was found guilty and was sentenced to one year's imprisonment, while Ishakak, who took only a minor part, and was to some extent under the domination of Eeriykoot, was acquitted. Eeriykoot will serve his sentence at Cambridge Bay, apparently not in close confinement and his punishment will in fact lie in his isolation from the rest of his own people in Boothia Peninsula.

It is hoped the trial will have the desired effect of bringing home to the Eskimo that assisted suicides are forbidden. The comparatively light sentence given Eeriykoot avoided, however, any unnecessary harshness toward an individual whose sense of filial duty and adherence to Eskimo custom led him to contravene the Criminal Code.

This trial illustrates well the difficulty of applying laws based on the usages of civilization to a people as remote as the Netsiliks, to whom tribal custom must still appear a more immediate obligation.

New U.S. vehicle for arctic transportation

On 3 November 1949 the U.S. Transportation Corps announced that it had sent two modified half-track vehicles north for testing. They hope that in the Arctic these half-tracks, modified from the type used by Tank Destroyer units in 1942, may be able to take the place of the 2½ ton truck farther south.

Mr. A. Stayer, an automotive engineer with the Transportation Corps Board, has been responsible for the modification work. This included redesigning the conventional track to give a greatly reduced low-ground pressure, and devising front traction plates, which when secured between the dual-wheel gives the latter the same basic characteristics as the half-track pattern. These half-track vehicles will be capable of carrying up to 6,000 lbs. and tests made, some of which were carried out in sand, indicated that there would be 7.3 lb. ground pressure per sq. inch. It is hoped that these half-tracks will be capable of travelling over ice and snow at speeds in excess of 15 miles an hour.

Greenland News from Denmark

Through the kindness of Capt. Ejnar Mikkelsen and Mr. Gert Andersen we have received the following information about Greenland affairs.

Fund for increasing cultural relations

The Danish Government has recently established a fund, with a capital of 750,000 Kr. ($108,000 U.S.), for the purpose of increasing cultural relations between Greenland and Denmark. The fund will be used for such things as making grants or loans to young Greenlanders for the purpose of studying in Denmark, for encouraging the exchange of Greenlandic and Danish literature, and for providing books for public libraries. In addition the Greenland Administration, under a different scheme, provides the funds for training a number of craftsmen and technicians for professions in Greenland. In September 1949 40 such persons were being trained.

Population statistics

The latest population figures for Greenland, published by the Greenland Administration in Copenhagen, date from 1947. Between 31 December 1946 and 31 December 1947 the native population increased by about 2 per cent, from 21,379 to 21,825. In 1947 20,403 natives lived in West Greenland, including Thule, the most northern district. The district of Julianehaab had the greatest population, 4,280, and Godthaab, with 1,994, the next. In the two Eastern Colonies, Angmagssalik and Scoresbysund, there were only 1,422 inhabitants.

In 1947 the birthrate for the whole of Greenland was 43.7 per thousand and the death-rate 22.5 per thousand. The excess of births over deaths, 21.2 per thousand, is nearly twice as great as in Denmark.

At the beginning of this century the population in East Greenland was definitely decreasing. Since that time there has been a steady increase, and a provisional estimate suggests that between 1947 and 1970 the population should increase by as much as 50 per cent.

Air communications

In 1949, for the first time there has been well-established air communication between Greenland and Denmark. The usual boats were not able to satisfy the large demands for transport to Greenland, so the Greenland Administration chartered an aircraft from the Scandinavian Airline System. The aircraft has primarily been used for the transport of experts and workers engaged in an extensive building program being carried out in Greenland. The need for increased communication with Denmark is a sign of the modernization of Greenland and of the movement away from cultural isolation.

Vacation homes for Greenlandic children

Following an appeal to the Danish Red Barnet (Save the Children Fund), that Greenlandic children might be included in the scheme for Dutch, French and other foreign children who have been convalescing in Denmark, Red Barnet has announced that a number of vacation homes will be established in Greenland for local children. It was considered that it would not be right to bring Greenlandic children to Denmark on account of the grave risk of their catching tuberculosis or children's diseases which might prove fatal. The first camp in Greenland has already been established this year in Tasermiut fjord, south of Julianehaab.

Distribution of fresh vegetables

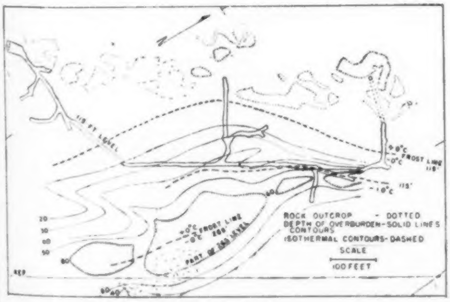
This year Danish market gardeners made a gift to the Greenlanders of a large amount of fresh vegetables. Free distribution was arranged in Greenland and it was hoped that by the enjoyment of the vegetables the Greenlanders would be encouraged to start growing some for themselves.

CORRESPONDENCE

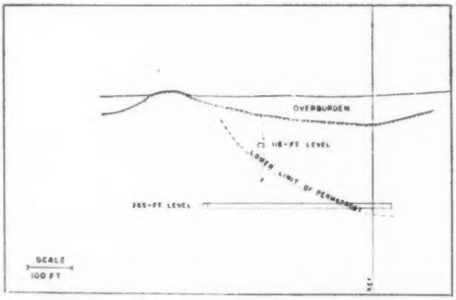
To the Editor:

The paper "Permafrost in Canada" by John L. Jenness appearing in the May, 1949, issue of *Arctic* is a valuable contribution to the knowledge of permafrost in Canada. Although widespread observations on permafrost have been made in this country, the published record of collected data is very limited.

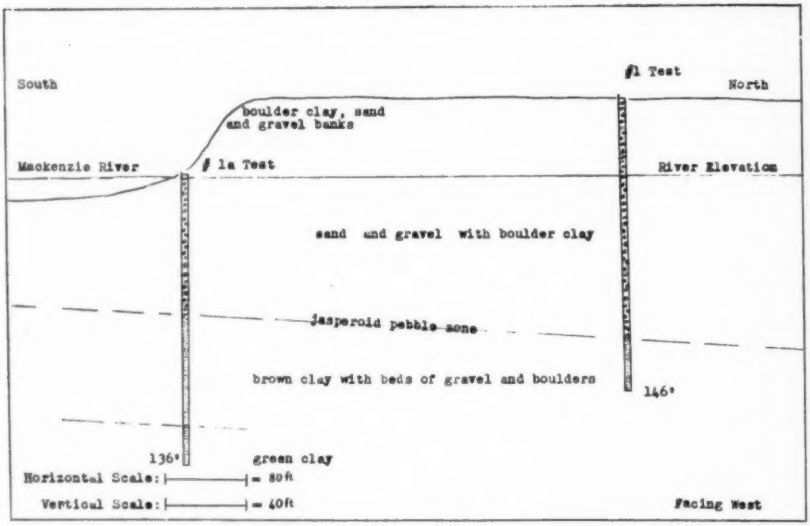
At Giant Yellowknife (see abstracts Royal Society of Canada, Section iv, Halifax meeting, June, 1949), considerable evidence has been accumulated to show that the depth of permafrost in bedrock is a function of the thickness (allowing for insulating qualities) of overburden, as indicated in the accompanying plan and section.



Composite plan of permafrost zone at Giant Yellowknife Mine.



Vertical section showing permafrost profile at Giant Yellowknife Mine.



Cross section of test holes at Fort Providence, N.W.T. (Permit 209).

One of the maps accompanying the paper indicates that continuous permafrost underlies the Yellowknife area. This is not so. Permafrost at Yellowknife is widespread; but not continuous. Excavations for the sewer and water system in the townsite encountered permafrost where clay was present; but in general, there is little permafrost in the sand deposits. Most of the townsite is laid out on a flat glacial outwash sand and gravel deposit, and several wells beneath buildings were sunk without encountering permafrost. Some of these wells have functioned summer and winter for years without trouble from frost.

At Giant Yellowknife and elsewhere in the district permafrost is present in deposits of clay four to six or more feet deep, particularly if there is some insulating vegetation such as moss. Nowhere in the district is permafrost known in exposed bedrock; but where the depth of overburden approaches or exceeds 60 feet permafrost is present in underground workings to a depth of at least 265 feet.[1]

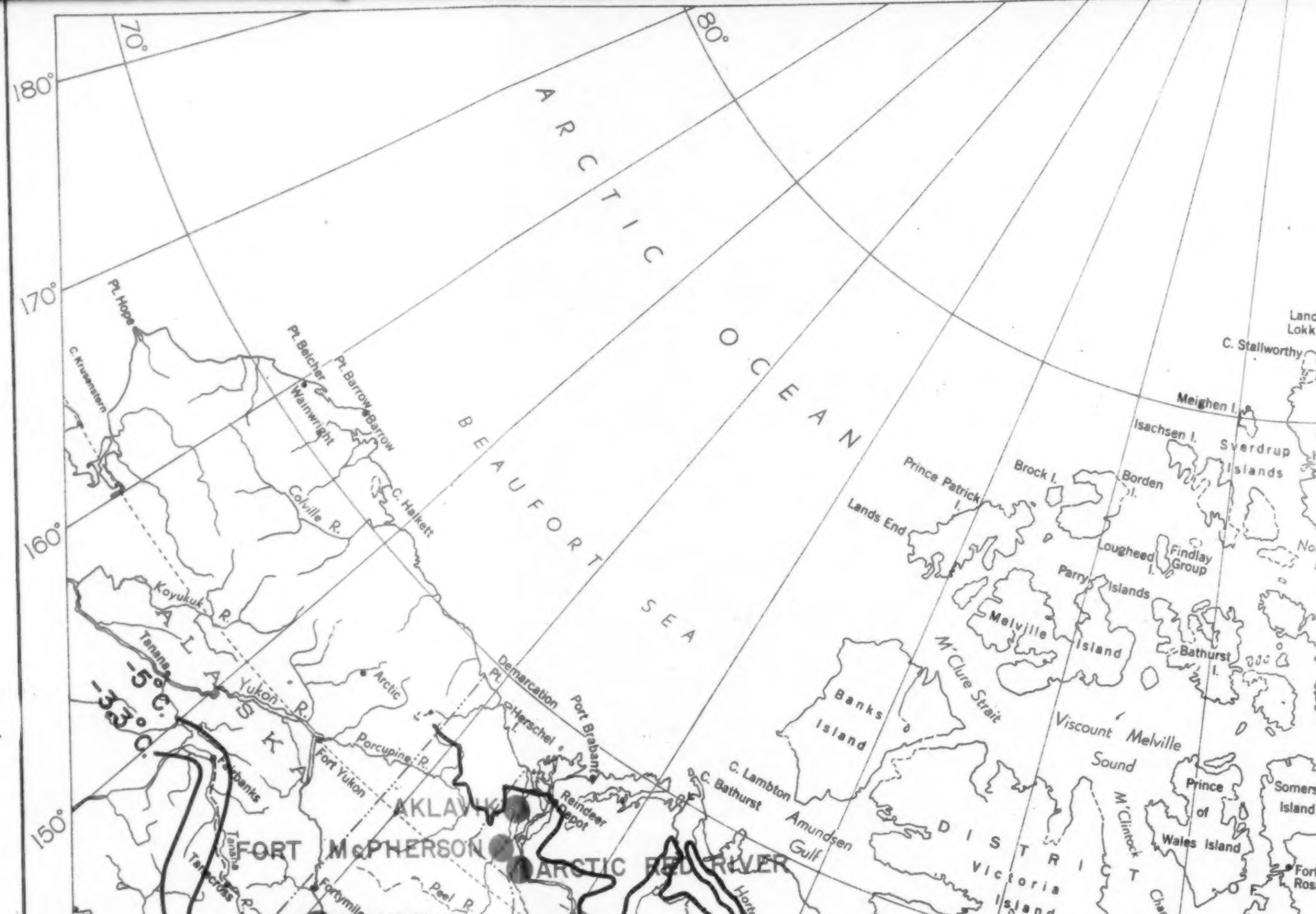
In diamond drilling at Giant Yellowknife it was found that, in holes at a vertical depth as much as 400 feet, freezing commenced at the bottom of the hole in each case and extended upwards at an accelerating rate as a rim of ice about the hole. Such freezing has commenced in holes beneath the lower limit of permafrost. Therefore, it is concluded that there is a transfer of heat within the hole.

The general conclusion is that the overburden has acted as an insulating blanket, protecting ancient permafrost. However, in the Slave Lake Gold mine (now Philmore Yellowknife) at Outpost Island in Great Slave Lake, permafrost was reported at a depth of 175 feet below the shaft collar. Outpost Island is a small rocky islet in the lake.

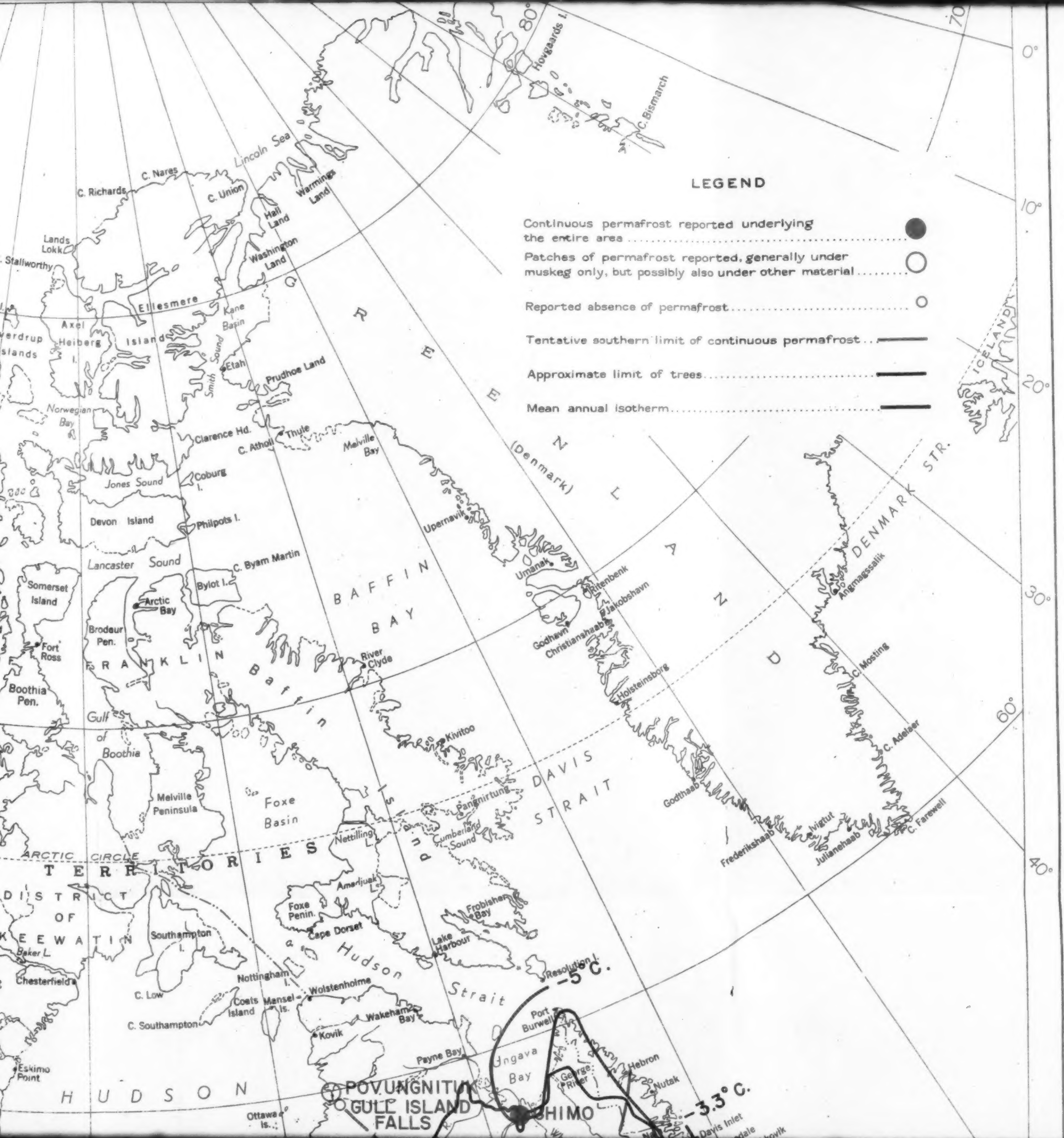
In July, 1949, two holes were drilled at Fort Providence to respective depths of 146 and 136 feet under the writer's direction. The holes intersected glacial and alluvial deposits underlain by lacustrine clays without encountering any frozen ground. Providence is indicated as lying in an area of continuous permafrost. One of the holes was drilled within 10 feet of the waterline of the Mackenzie River; the other was drilled 440 feet inland (see accompanying cross section of holes).

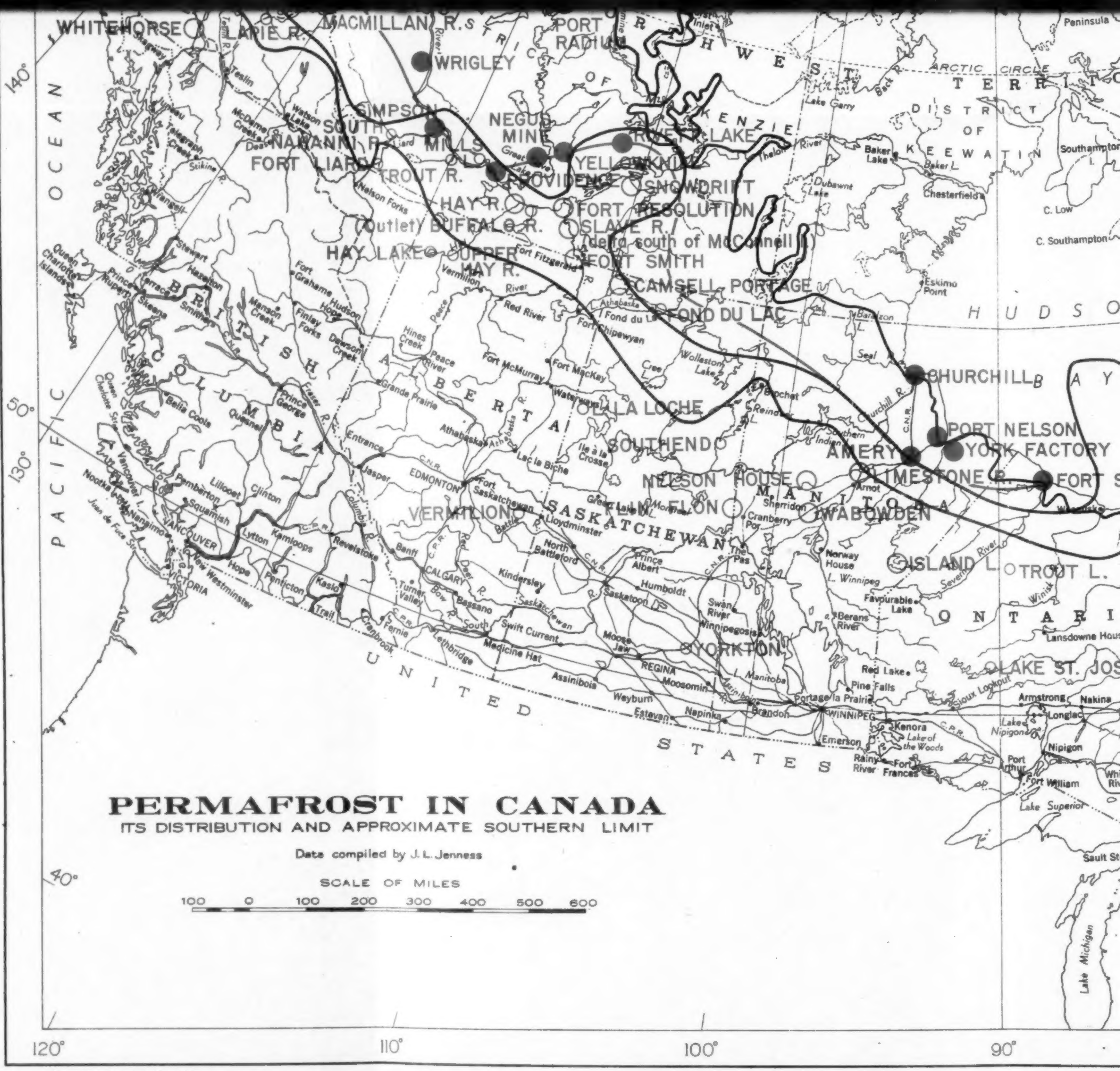
J. D. Bateman
Giant Yellowknife Gold Mines Ltd.
Yellowknife, N.W.T.
28 July 1949

[1]The diagrams in this letter are reproduced by permission of Section IV of the Royal Society of Canada, 1949.



ARCTIC OCEAN
BEAUFORT SEA
ALASKA
-5°C.
-33°C.
AKLAVIK
FORT McPHERSON
ARCTIC RED RIVER
DAWSON
MAYO
KENO
FORT GOOD HOPE
NORMAN WELLS
FORT NORMAN
PORT RADIUM
AISHIHIK
CARMACKS
BEAR PASS SUMMIT
TAKHINI R.
WHITEHORSE
LAPIE R.
MACMILLAN R.
WRIGLEY
SIMPSON
SOUTH NAHANNI R.
FORT LIARD
MILLS L.
TROUT R.
NEGUS MINE
YELLOWKNIFE
PROVIDENCE
SNOWDRIFT
HAY R.
FORT RESOLUTION
(Outlet) BUFFALO R.
SLAVE R. / (delta south of McConnell)
HAY LAKE
UPPER HAY R.
FORT SMITH
CAMSELL PORTAGE
FOND DU LAC
Banks Island
Victoria Island
Amundsen Gulf
Coronation Gulf
Viscount Melville Sound
M'Clure Strait
Melville Island
Prince Patrick I.
Brock I.
Borden I.
Isachsen I.
Meighen I.
Sverdrup Islands
C. Stallworthy
Lougheed I.
Findlay Group
Parry Islands
Bathurst I.
Prince of Wales Island
Boothia Pen.
King William I.
Cambridge Bay
Coppermine
Bathurst Inlet
Baker Lake
Dubawnt Lake
Lake Garry
Eskimo Point
Chesterfield
Pt. Hope
Pt. Barrow
Barrow
Wainwright
Pt. Belcher
C. Krusenstern
C. Halkett
Colville R.
Koyukuk R.
Yukon R.
Porcupine R.
Fort Yukon
Peel R.
Tanana
Cordova
Demarcation Pt.
Herschel I.
Port Brabant
Reindeer Depot
C. Lambton
C. Bathurst
Lands End
Horton R.
Thelon River
Back R.
Stewart
Teslin
Watson Lake
Dease Lake
Telegraph Creek
Stikine
Juneau
Prince Rupert
Terrace
Smithers
Hazelton
Skeena
Queen Charlotte Islands
Fort Grahame
Hudson Hope
Finlay Forks
Manson Creek
Nelson Forks
Fort Fitzgerald
Vermilion
Red River
Peace
Fort Chipewyan
Athabaska
Fond du Lac
Great Bear L.
Great Slave Lake
DISTRICT OF MACKENZIE
DISTRICT OF KEEWATIN
NORTHWEST TERRITORIES
OCEAN
70°
80°
180°
170°
160°
150°
140°
60°


LEGEND
Continuous permafrost reported underlying the entire area
Patches of permafrost reported, generally under muskeg only, but possibly also under other material
Reported absence of permafrost
Tentative southern limit of continuous permafrost
Approximate limit of trees
Mean annual isotherm
GREENLAND
(Denmark)
BAFFIN BAY
DAVIS STRAIT
DENMARK STR.
ICELAND
Lincoln Sea
Hougaards I.
C. Bismarch
C. Richards
C. Nares
C. Union
Hall Land
Warmings Land
Washington Land
Lands Lokk
Stallworthy
Ellesmere Island
Axel Heiberg I.
Kane Basin
Smith Sound
Etah
Prudhoe Land
Norwegian Bay
Clarence Hd.
C. Atholl
Thule
Melville Bay
Jones Sound
Coburg I.
Devon Island
Philpots I.
Lancaster Sound
C. Byam Martin
Bylot I.
Somerset Island
Arctic Bay
Brodeur Pen.
Fort Ross
FRANKLIN
Boothia Pen.
Gulf of Boothia
Baffin Island
River Clyde
Upernavik
Umanak
Ritenbenk
Jakobshavn
Godhavn
Christianshaab
Holsteinsborg
Angmagssalik
C. Mosting
C. Adelaer
Kivitoo
Melville Peninsula
Foxe Basin
Pangnirtung
Cumberland Sound
Godthaab
Frederikshaab
Ivigtut
Julianehaab
C. Farewell
Nettilling L.
ARCTIC CIRCLE
TERRITORIES
DISTRICT OF KEEWATIN
Baker L.
Amadjuak L.
Foxe Penin.
Cape Dorset
Frobisher Bay
Lake Harbour
Southampton I.
Chesterfield
Hudson Strait
Resolution I.
-5°C.
Nottingham I.
Wolstenholme
C. Low
Coats Island
Mansel Is.
C. Southampton
Wakeham Bay
Port Burwell
Kovik
Payne Bay
Ungava Bay
George River
Hebron
Nutak
-3.3°C.
Eskimo Point
HUDSON
POVUNGNITUK
GULL ISLAND FALLS
CHIMO
Ottawa Is.
Davis Inlet
80°
70°
60°
0°
10°
20°
30°
40°



PERMAFROST IN CANADA

ITS DISTRIBUTION AND APPROXIMATE SOUTHERN LIMIT

Data compiled by J. L. Jenness

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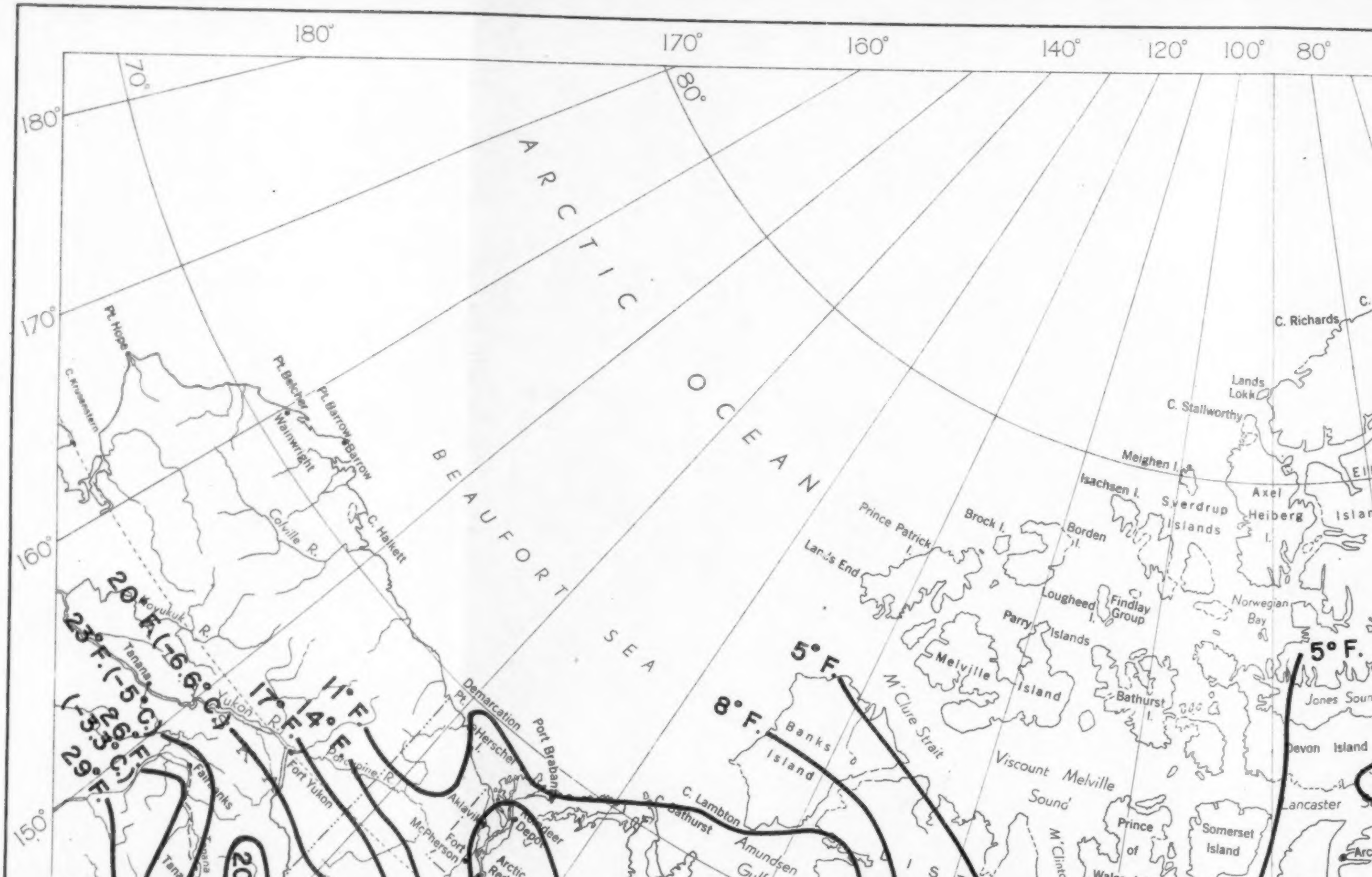
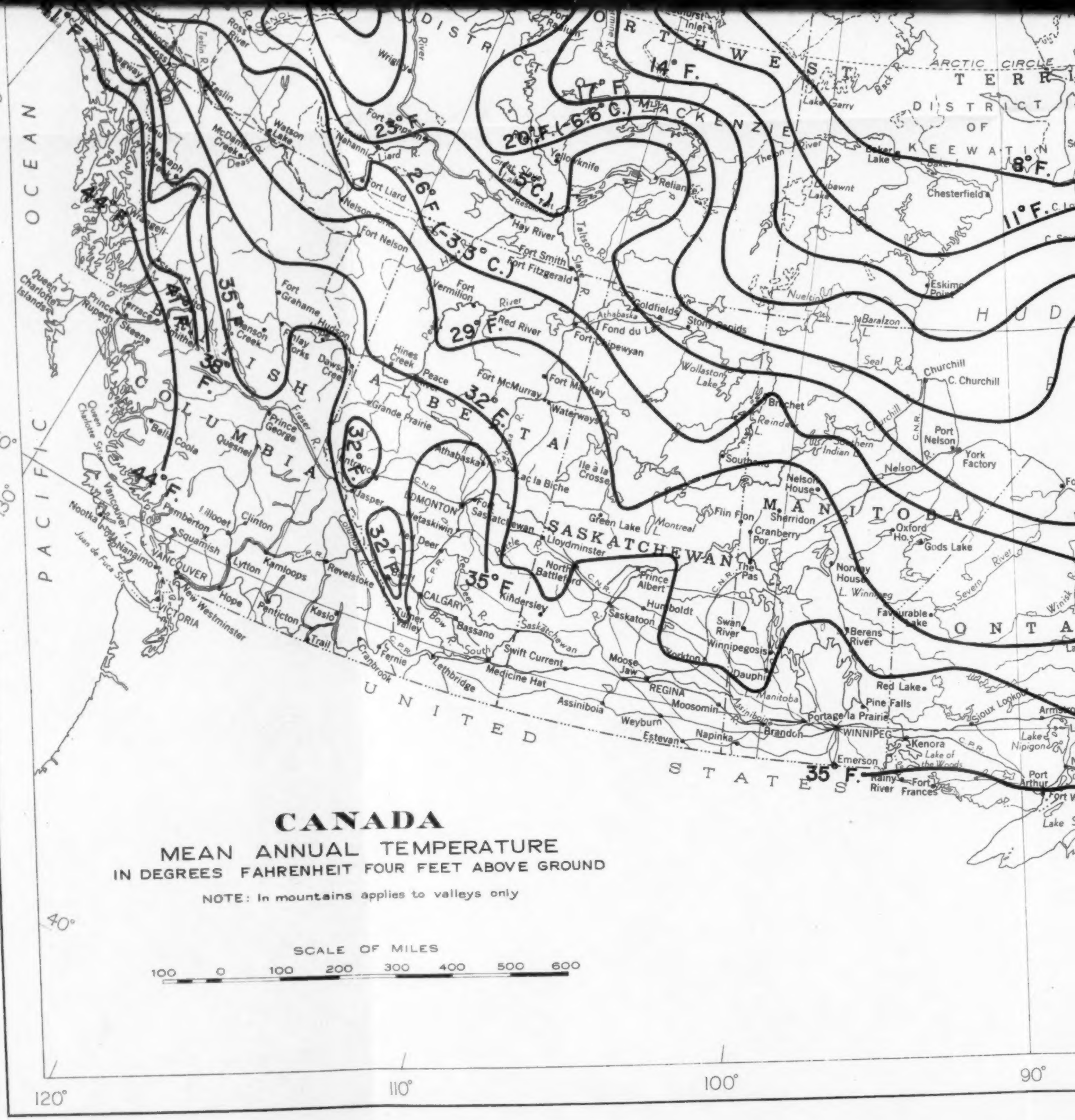


ARCTIC OCEAN
BEAUFORT SEA
180°
170°
160°
150°
140°
120°
100°
80°
70°
60°
Pt. Hope
C. Krusenstern
Pt. Belcher
Wainwright
Pt. Barrow
Barrow
C. Halkett
Colville R.
Koyukuk R.
Tanana
Yukon R.
Porcupine R.
Fort Yukon
Fairbanks
Fortymile
Dawson
Stewart R.
Mayo Ldg.
Carmacks
Pelly R.
Ross River
Teslin R.
Teslin
Watson Lake
McDame Creek
Dease R.
Skagway
Wrangell
Queen Charlotte Islands
Demarcation Pt.
Herschel I.
Port Brabant
Aklavik
Fort McPherson
Arctic Red River
Reindeer Depot
Peel R.
Mackenzie R.
Good Hope
Norman
Fort Franklin
Great Bear L.
Port Radium
Coppermine
Coppermine R.
Fort Norman
Wrigley
Fort Simpson
Nahanni
Liard R.
Fort Liard
Fort Nelson
Hay River
Fort Smith
Fort Fitzgerald
Fort Vermilion
Fort Grahame
Great Slave Lake
Yellowknife
Reliance
Resolution
Taltson R.
Slave R.
Thelon River
Lake Garry
Back R.
Baker Lake
Dubawnt Lake
Chesterfield
C. Lambton
C. Bathurst
Amundsen Gulf
Banks Island
Horton R.
Victoria Island
Coronation Gulf
Cambridge Bay
Bathurst Inlet
King William I.
Prince Patrick
Lands End
Brock I.
Borden I.
Lougheed I.
Findlay Group
Parry Islands
Melville Island
Bathurst I.
M'Clure Strait
Viscount Melville Sound
Prince of Wales Island
M'Clintock Channel
Somerset Island
Fort Ross
Boothia Pen.
Gulf of Boothia
Brodeur Pen.
Isachsen I.
Meighen I.
Sverdrup Islands
Axel Heiberg I.
Norwegian Bay
C. Stallworthy
Lands Lokk
C. Richards
Jones Sound
Devon Island
Lancaster
ARCTIC CIRCLE
YUKON
DISTRICT OF MACKENZIE
NORTHWEST TERRITORIES
DISTRICT OF KEEWATIN
DISTRICT OF FRANKLIN
OCEAN
Gulf of Alaska
5° F.
8° F.
11° F.
14° F.
17° F.
20° F. (-6.6° C.)
23° F. (-5° C.)
26° F. (-3.3° C.)
29° F.
32° F.
35° F.
38° F.
41° F.
44° F.
20° F.

80°
60°
40°
20°
10°
0°
80°
70°
0°
10°
20°
30°
60°
40°
Hovgaards I.
C. Bismarch
Shannon I.
Lincoln Sea
C. Nares
Richards
C. Union
Hall Land
Warmings Land
Washington Land
Ellesmere
Island
Kane Basin
Smith Sound
Etah
Prudhoe Land
G R E E N L A N D
(Denmark)
C. Brewster
ICELAND
DENMARK STRAIT
Clarence Hd.
C. Atholl
Thule
Melville Bay
5° F.
Jones Sound
Coburg
8° F.
Devon Island
Upernavik
Lancaster Sound
C. Byam Martin
Bylot I.
Arctic Bay
B A F F I N
B A Y
Umanak
Ritenbenk
Jakobshavn
Angmagssalik
Godhavn
Christianshaab
F R A N K L I N
River Clyde
Holsteinsborg
C. Mosting
Baffin
5° F.
Boothia
Kivitoo
11° F.
14° F.
DAVIS STRAIT
C. Adelaer
Melville Peninsula
Foxe Basin
Pangnirtung
Godthaab
Cumberland Sound
17° F.
Nettilling L.
T E R R I T O R I E S
C. Farewell
Frederikshaab
Ivigtut
Julianehaab
20° F. (-6.6° C.)
Amadjuak L.
Southampton I.
Cape Dorset
Lake Harbour
Hudson Strait
23° F. (-5° C.)
Resolution I.
Nottingham
Coats Island
Mansel Is.
Wolstenholme
Wakeham Bay
Port Burwell
Kovik
C. Southampton
14° F.
Payne Bay
Ungava



CANADA

MEAN ANNUAL TEMPERATURE
IN DEGREES FAHRENHEIT FOUR FEET ABOVE GROUND

NOTE: In mountains applies to valleys only

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